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THE RELATIONSHIP BETWEEN CLASSIFICATION OPERATIONS WITH CONCRETE AND PRINT STIMULI AND READING COMPREHENSION AT THREE GRADE LEVELS

by

Ⓒ CAROL ANNE INGLIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "The Relationship Between Classification Operations with Concrete and Print Stimuli and Reading Comprehension at Three Grade Levels" submitted by Carol Anne Inglis in partial fulfilment of the requirements for the degree of Master of Education.

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Date June 13, 1974

ABSTRACT

Reading and thinking are two important interrelated skills which students in elementary school are expected to learn. There is evidence that children need to be able to think in order to read with comprehension. The purpose of this study was to examine the relationship between classificatory thinking and reading comprehension. Classification skills were measured by two test batteries, one using concrete stimuli and the other using print stimuli.

The sample consisted of forty-five grade four, five and six children chosen from the total populations of each of the grades in one school by a table of random numbers.

Two classification test batteries were individually administered to each student. The student's reading vocabulary score and reading comprehension score from the Canadian Test of Basic Skills, which were recorded in the school cumulative records, were used. The stud[illegible]'s verbal intelligence score and non-verbal intelligence score from the Lorge-Thorndike Intelligence Tests, which were also in the cumulative records, were also used.

The classification tests used in this study were derived from the classification tests constructed by Rawson (1969). The general format of both batteries was to first present a stimulus situation, and then to present questions about the situation which involved classificatory operations. The types of classification measured were class inclusion relations, predicates, and multiplicative classes.

Correlations, t-tests, z-tests, analysis of variance and analysis of co-variance were used in the statistical analysis of the data.

Findings showed that boys and girls perform in a similar manner on both print and concrete classification tasks. Findings also showed that concrete classification tasks were significantly easier than print classification tasks at each grade level, and that at the grade six level the difference between the two modes is significantly greater than at the grade four and grade five levels. No significant correlations between the batteries were found except at the Grade six level and for the total group. No significant correlations were found to exist between concrete and print classification scores and reading vocabulary, reading comprehension, verbal intelligence and non-verbal intelligence scores in terms of the latter factors contributing to a higher classification score. Significant correlations were found between reading comprehension and concrete classification for the grade five group, and between reading comprehension and print classification for the grade five and grade six groups, implying that print classification tasks are more closely related to reading comprehension than concrete classification tasks.

The results of the study indicate that assumptions should not be made about how a child will perform classificatory thinking in a concrete mode based on his performance in a print mode, or vice versa. The results also imply that assumptions should not be made about a child's ability to perform classificatory thinking on the basis of standardized reading and intelligence scores and vice versa.

Educational implications of these findings were discussed as

were suggestions for further research in this area.

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TABLE OF CONTENTS

Page

LIST OF TABLES.. xiii

LIST OF FIGURES.. xv

Chapter

I. INTRODUCTION AND PROBLEM.................................... 1

  Purpose of the Study.. 2

  The Sample.. 3

  Data Collection and Analysis................................ 3

  Definitions... 3

  Hypotheses.. 4

  Assumptions... 5

  Limitations... 6

  Significance of the Study................................... 6

  Overview of the Study....................................... 7

II. REVIEW OF RELATED LITERATURE............................... 8

  Nature of Classification.................................... 8

    Types of Classifications.................................. 10

    Criteria of Classification................................ 12

    Measuring Classificatory Behavior......................... 14

    Summary... 17

  Theories about Classificatory Development................... 18

    Some of the Differences between Child and Adult Thinking.. 19

    Summary... 29

    Reasons for the Differences between Child and Adult Thinking... 29

Chapter Page

Summary.. 32

Relationship of Classification Ability to Reading Achievement.......................... 33

Is There a Relationship between Classification Ability and Reading Achievement?.......................... 33

Using Classification While Reading.............. 37

Value of Knowing About the Relationship of Classification and Reading................. 40

Summary.. 42

Summary.. 43

III. THE DESIGN OF THE STUDY.............................. 45

Introduction....................................... 45

The Sample... 45

Standardized Test Instruments...................... 47

Lorge-Thorndike Intelligence Test............... 47

Canadian Tests of Basic Skills.................. 48

The Experimental Test Instruments.................. 49

Validity and Reliability of the Experimental Tests............................. 52

Administration of the Experimental Tests.......... 56

Scoring Procedure.................................. 57

Reliability of the Scoring......................... 58

The Pilot Study.................................... 59

Statistical Procedures............................. 60

Summary.. 62

Chapter Page

IV. ANALYSIS AND INTERPRETATION OF DATA................ 63

Introduction.................................... 63

Description of the Sample....................... 63

Comparison of the Scoring Method Developed for this Study and the Rawson Method of Scoring.. 65

Order of Test Presentation Effect............... 75

Sex Differences on Experimental Measures......... 76

Other Factors Affecting Classification Scores... 79

Summary...................................... 81

Relationship of Classification Ability in Print Mode and Concrete Mode Over Three Grade Levels..................................... 81

Relationship of Classification Ability and Reading Comprehension Over Three Grade Levels.. 84

Correlations.................................. 84

Significance of the Difference Between the Correlations of Classification and Reading Comprehension Among the Grade Levels........... 91

Summary...................................... 94

Analysis of the Class Inclusion Subtest.......... 94

Summary...................................... 105

Summary... 107

V. SUMMARY, CONCLUSIONS, IMPLICATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH.................... 109

Summary... 109

Findings and Conclusions........................ 109

Chapter | Page

Analysis of the Class Inclusion Subtest.......... 116

Limitations of the Study........................ 116

Implications of the Study....................... 117

Suggestions for Further Research................ 118

BIBLIOGRAPHY.. 121

APPENDICES Page

APPENDIX A. TEN CHARACTERISTICS OF TRUE CLASSIFICATION WITH THOSE PRESENT AT THE CONCRETE STAGE ASTERISKED.................... 131

APPENDIX B. MATERIALS FOR PRINT BATTERY........... 134

MATERIALS FOR CONCRETE BATTERY........ 138

APPENDIX C. SYMBOLIC REPRESENTATIONS OF THE TEST ITEMS FOR THE PRINT AND CONCRETE BATTERIES.................. 139

APPENDIX D. PRINT CLASSIFICATION TEST BATTERY..... 153

CONCRETE CLASSIFICATION TEST BATTERY.. 160

APPENDIX E. SUMMARY OF THE TWO TEST BATTERIES SHOWING THE PARALLEL CONSTRUCTION... 169

LIST OF TABLES

Table	Description	Page
1	Description of the Sample........................	64
2	Summary of Scores on the Classification Tasks...	66
3	Summary of Scores on the Classification Tasks Using Rawson Scoring.....................	72
4	Summary of Percent Correct on Classification Tests..........................	73
5	Correlations Between the Classification Scores Obtained Using the Scoring Method Developed for this Study with the Rawson Method....................................	74
6	Effect of the Order of Presentation of Tests....	77
7	Differences Between Boys and Girls on the Classification Tasks......................	78
8	Relationship of Classification Scores to Reading and Intelligence Scores.................	80
9	Change in Classification Test Scores Over the Grade Levels - Two Factor Analysis of Variance with Repeated Measures on Factor 'B'..	85
10	Correlations Between Concrete and Print Tasks....	87
11	Correlations Between Reading Comprehension and Classification Test Scores.................	89
12	Significance of the Difference Between the Grades of the Correlations Between Concrete Classification and Reading Comprehension........	92
13	Significance of the Difference Between the Grades of the Correlations Between Print Classification and Reading Comprehension........	93
14	Scores on the Classification Subtests Class Inclusion and Multiplication Showing Answer (A) and Explanation (E) Totals Separately.......	96

Table		Page
15	Average Scores Obtained on Class Inclusion Items Grouped According to Operations Being Tested	101
16	Answers-Only Scores on the Class Inclusion Subtest	103
17	Correlations Between VIQ, QIQ, RV, RC, and CCI, PCI, and CIN, PIN	106
18	Readability Scores for the Print Test Materials	137

LIST OF FIGURES

Figure Page

1 Frequency Distributions of Correct Scores on the Class Inclusion Subtest for the Three Grade Levels.................................. 67

2 Frequency Distributions of Correct Scores on the Predicate Subtest for the Three Grade Levels.................................. 68

3 Frequency Distributions of Correct Scores on the Multiplicative Subtest for the Three Grade Levels............................ 69

4 Frequency Distributions of Correct Scores on the Total Battery for the Three Grade Levels.................................. 70

5 Mean Scores on the Class Inclusion and Multiplicative Subtests........................ 82

6 Mean Scores on the Predicate Subtest and the Total Battery............................... 83

7 A Comparison of the Class Inclusion Scores at each Grade Level Using Answers-Only (CIN and PIN) and Answers-Plus-Explanation (CCI and PCI) Scores.......................... 104

CHAPTER I

I. INTRODUCTION AND PROBLEM

Reading and thinking are two important skills which students in elementary school are expected to learn. During the latter part of the concrete operations stage, about age seven to eleven years, as defined by Inhelder and Piaget (1958), students are gaining competence in both reading and thinking. Evidence that children need to be able to think in order to read with comprehension has been obtained in studies by J. S. Braun (1963) and Furth (1966).

Because thinking is a mental activity, it is impossible to observe it directly. Therefore psychologists who study thinking have developed certain methods of indirectly observing thinking by eliciting behavior in response to stimuli. By controlling the stimulus situation carefully they are able to develop theories about thinking.

To test a student's thinking Piaget has developed tests and methods of observation which seem to measure thinking ability. Piaget, and many investigators who have tried to replicate his findings, used concrete objects for a stimulus situation or an oral-verbal presentation.

Rawson, in 1969, conducted a study to examine whether cognitive processes were equally developed in children when material was presented in a print-verbal mode and when material was presented in a concrete mode. Using children of average intelligence and average reading ability at the Grade four level, Rawson undertook an examination of five types of thinking: conservation, classification, induction, deduction, and probability. She found that children did better with a concrete stimulus than a print stimulus in all types of thinking tested.

In 1971 McRae replicated one section of Rawson's study, that dealing with inductive thinking. He tested Grade four and Grade six children. The children did better with a concrete stimulus than a print stimulus, confirming Rawson's findings.

Since, according to Bruner, Goodnow, and Austin (1962), virtually all cognitive activity involves and is dependent on the process of categorizing, children need to be able to classify when reading. Further study of classification skills therefore seems to be necessary in order to obtain a greater insight into the relationship between classification ability and reading comprehension.

The problem to be examined in this study is to ascertain how well children classify, in which mode they perform best, whether or not there is a developmental aspect in this particular cognitive ability, and how their classificatory performance relates to their reading comprehension performance.

II. PURPOSE OF THE STUDY

The purpose of this study was to examine the relationship between classification scores, on tests using both concrete stimuli and print stimuli, and reading comprehension scores, at three grade levels:

four, five, and six, and to determine whether there was a change in the relationship between the grade levels. The relationship between the students classificatory performance in each mode, concrete and print, will also be examined at each of the grade levels and over the grade levels.

III. THE SAMPLE

Forty-five students, fifteen from each of the three grades, four, five, and six, were chosen from the total population of two hundred and forty-one students in one school in Edmonton, Alberta, by means of a table of random numbers.

IV. DATA COLLECTION AND ANALYSIS OF THE DATA

Two classification test batteries, one using concrete stimuli, the other using print stimuli, were administered to the students individually. Reading scores and intelligence quotient scores recorded in the cumulative record cards for each child were used.

Statistical analyses used were correlations, t-tests, z-tests, analysis of variance and analysis of covariance.

V. DEFINITIONS

Concrete Mode - a mode of presentation in which stimuli are actual objects which the children can manipulate (McRae, 1971).

Print Mode - a mode of presentation in which the stimuli are typewritten stories (McRae, 1971).

Class - the totality of objects having a certain property (Rawson, 1969).

Classification Operation - components in an intellectual process by which one reality state is transformed into another in the context of assumed available class and class inclusion structures; the operations may be indicated symbolically . . . the outcomes may also be represented symbolically and may be observed as verbal responses (Rawson, 1969).

Reading Comprehension - the amount of meaning an individual is able to extract from printed material as measured by the Canadian Test of Basic Skills.

VI. HYPOTHESES

1. There is no significant difference between the scores attained by boys and girls on the concrete or print classificatory batteries.
2. There is no significant change over the three grade levels in the correlation between the scores attained on the concrete classificatory battery and reading vocabulary, reading comprehension, verbal intelligence and non-verbal intelligence.
3. There is no significant change over the three grade levels in the correlation between the scores attained on the print classificatory battery and reading vocabulary, reading comprehension, verbal intelligence, and non-verbal intelligence.
4. There is no significant interaction between mode and grade for the print and concrete classificatory test batteries over the

three grade levels.

5. There is no significant difference between the modes at each grade level.
6. There is no significant change in the difference between the modes over the three grade levels.
7. There is no significant correlation between classification scores in the print mode and in the concrete mode at each grade level.
8. There is no significant difference in the correlation between print classification scores and concrete classification scores over the grade levels.
9. There is no significant correlation between reading comprehension scores and classification scores in the concrete mode and in the print mode at each grade level.
10. There is no significant difference in the correlation between reading comprehension scores and classification scores over the three grade levels.

VII. ASSUMPTIONS

It was assumed that the IQ scores and reading scores taken from the cumulative records were accurate indicators of performance in these areas for the members of the sample.

It was assumed that the sample was representative of the population of Grade four, five and six students in the school from which it was obtained.

VIII. LIMITATIONS

The following factors are recognized as limiting the generalizations made from the data collected in this study.

1. Generalizations for this study will be possible only to a population of children in Grades four, five and six in an area similar to the area of Edmonton that was sampled.

2. Generalizations will be possible only to classificatory operations similar in nature to those used in the testing instruments.

IX. SIGNIFICANCE OF THE STUDY

The study may provide insights into the relationship between classification skills and reading comprehension, in upper elementary school children. If this is significant it may have implications for the teaching of reading comprehension skills of a classificatory nature.

It may help to pinpoint specific classificatory operations that are most frequently found to be difficult in reading comprehension activities. If so, this could have implications for evaluating and teaching classificatory reading comprehension skills.

The study may indicate the degree of correspondence that exists between doing a particular classificatory operation in a print mode and in a concrete mode. This could have implications for teaching and for evaluating children's performance in subjects such as Science and Mathematics, in which concrete materials are used to facilitate understanding of concepts which are to be presented verbally later.

X. OVERVIEW OF THE STUDY

In Chapter I the purpose for the study was established.

Chapter II is a presentation of literature related to the various aspects of the study.

Chapter III describes the sample, the test instruments employed, a summary of the pilot study and the statistical procedures to be used to analyse the data.

In Chapter IV the results of the statistical analyses are presented and interpreted.

Chapter V contains the conclusions of the study, implications, and suggestions for further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

Three major theoretical concerns related to the research are dealt with in this chapter. Firstly, the nature of classification is discussed. Secondly, the developmental nature of classification is examined, and thirdly, the relationship between classification skills and reading comprehension is reviewed.

I. NATURE OF CLASSIFICATION

Humans classify because it is an effective way of adjusting to their environment states Bruner, Goodnow, and Austin (1962) and E. B. Hunt (1966). They suggest that classifying reduces the complexity of the environment, reduces the need for constant learning, provides direction for instrumental activity, and allows ordering and relating of classes of events. According to Britton (1970) classifying facilitates information processing and makes higher thought processes possible. He suggests that it is a way of relating the unfamiliar to the familiar, or, the old to the new.

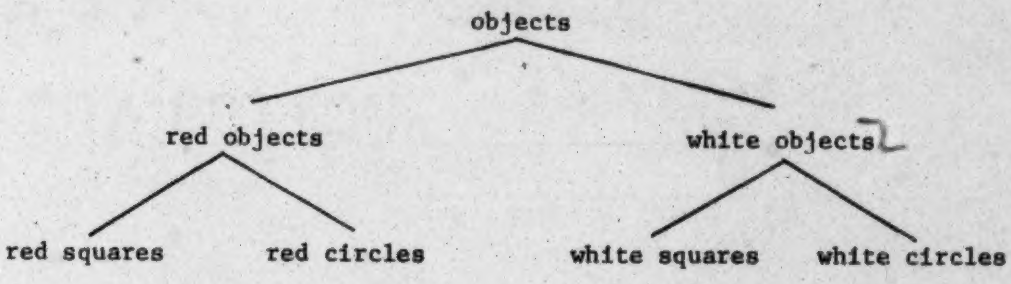
Classification seems to be a logical operation performed by a person upon objects, events, people or ideas. The dictionary definition of logical is "according to the principles of logic". Operation is defined by Ginsburg and Opper (1969, p. 150) as an action that is performed mentally. For a logical operation such as classification to be performed upon objects, events, people or ideas means that the person who is classifying decides in his mind that groups or classes could be formed with them, and divides them up accordingly. In this way a person recognizes that a group of red objects and a group of white objects can be combined to form one group of red and white objects.

Bruner, Goodnow, and Austin (1963) believe classification involves the identification and abstraction of common properties or principles among things, which are then grouped into separate classes according to certain common properties. To identify a property of something, a person has to be able to recognize that feature, and have a mental symbol of it; for example, redness. If there are many things that have that feature, for example red squares, red circles, red triangles, and red rectangles, he must be able to mentally isolate or abstract the feature of redness as a property common to all of these items. He then is able to group the objects together producing a class of 'reds'.

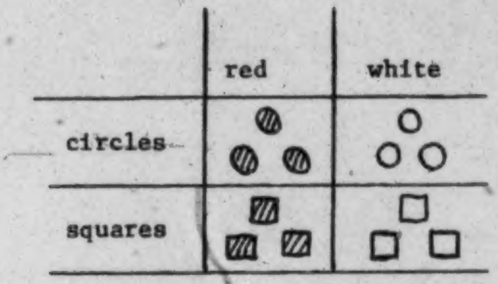
Britton (1970, p. 23) claims that all classifications are inventions of human beings. Divisions between classes are arbitrarily established depending upon the need and convenience of certain societies. Brown (1962) and Organ (1965, p. 33) state that the set of principles that define the bounds of classification therefore have to be learned. It seems, furthermore, that competence with classifying and understanding classifications may well be a matter of concern to educators since these skills are learned, and are not innate.

Types of Classifications

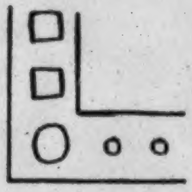
The basic types of classifications examined by Rawson (1969) are simple class inclusion groupings, additive groupings, and multiplicative groupings. Simple class inclusion groupings are observed when things are divided up into groups without necessary relations between groups being adhered to. For example, unrelated objects such as toy cars, buttons, and beads can be divided into three specific groups: toy cars, buttons, and beads. Additive groupings result in hierarchical structures with groups related to sub-groups in superordinate and subordinate relations. For example, objects such as red squares, red circles, white squares and white circles can be divided into classes that are related in an order such as the following:

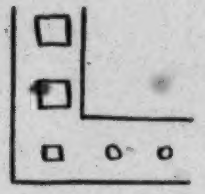


Multiplicative groups may be of two forms, a matrix or an intersection. Matrix groups are formed by systematically mixing established classes to form a new group. This can be illustrated using the classes whites, reds, circles, and squares. The new groups formed are red circles, white circles, red squares, and white squares.



An intersection grouping is formed when two attributes, one from each of two established classes, are joined to form a new group. This can be illustrated using the classes large squares and small circles. Either a large circle or a small square can be placed at the point of intersection





These basic types of classifications represent the two directions for classifying that are possible, horizontal and vertical. Horizontal classifications would follow the pattern of simple classifications. The classes are mutually exclusive and about equal in inclusiveness; that is, particular items can fit into only one class and have attributes that are definitive of only one class. Vertical classifications would follow the pattern of additive and multiplicative classifications. In these classifications the classes are interdependent. Classes are grouped and re-grouped in a superordinate, subordinate relationship; or, new classes are formed by combining established classes.

Criteria of Classification

Many researchers have examined classificatory criteria, which are those characteristics of objects, events, people or things, that are used as a basis for grouping into classes. Examples of attribute criteria are shape, color, and size. Examples of property criteria are habits of animals, or behavior of societies. In this section the types of criteria preferred at particular age levels, and the quantity of different criteria that can be applied to one set of things at different age levels, will be discussed.

Many studies have been done to determine the types of criteria different groups of children prefer to use when classifying and the results obtained in these studies are consistent. Early elementary school-aged children (Kindergarten to Grade one) usually make classifications on the basis of perceptual criteria report Britton, (1970) and Sigel (1967). Further to this it seems that color is the preferred perceptual criterion at this age. Denney (1972) suggests that older children seem to prefer form. It is believed by Spellman (1968) that this shift from color to form may be due mainly to the influence of schooling. Size is less used than either color or shape according to Fraser and Ross (1970).

Britton (1970) reports that usually middle elementary school-aged children make classifications on the basis of functional criteria, while older elementary school-aged children group on the basis of conventional names. Definitions of these types of criteria were developed by Gerstein. These were quoted in a thesis by Jackson (1968, p. 30), and shall be used to explain the meaning of functional criteria and conventional names. In using functional criteria, a word is defined by the child recalling the use to which that object was put in the past, e.g., "an apple is something you eat," or "a donkey is something you ride on". To group on the basis of conventional names the child is employing an "abstract" attitude, or "conceptual method". "An apple is a fruit" is an example of grouping in this way.

Authors who have also found a change with age similar to that just described include Thompson (1941), Parker, Halbrook (1969), Sigel (1954), (1967), Annett (1959), Goldman and Levine (1963), and Jackson (1968).

Birch and Bortner (1966) tested individuals between three and ten years of age to see if a category choice was made by preference or because of lack of ability with other types of criteria. They discovered that the choice seems to be one of preference to a significant extent, because all age groups could use functional criteria if no perceptual criteria were applicable. Lee, Kagan and Robson (1963), like Birch and Bortner, believe that differences between criteria used by children to categorize may be due mostly to preference. They believe this preference is an indication of their learning style rather than an indication of their actual reasoning ability. Be that as it may, performance with all types of criteria improves with age, and performance at all levels is better with perceptual criteria than with functional and abstract criteria, state Parker and Day (1971).

Several studies on classification have yielded the finding that the quantity of criteria which can be applied to one set of objects increases with the age of the student. These studies were reported by Inhelder and Piaget (1964), Reichard (1944), Kofsky (1966), Croxton (1965), and Blackford (1970). The very young can apply none, the pre-schoolers can apply one, and older children can apply two or more. For example, given a set of red squares, white squares, red circles, and white circles, very young children can be expected to group the objects randomly; pre-schoolers would probably group them into white and red sets, employing the criteria of color; and, older children would probably group them by both color and shape into four sets: red squares, white squares, red circles and white circles.

Measuring Classificatory Behavior

In order to measure a logical operation it is necessary to externalize the behavior, set test objectives for the subjects, and work with units larger than single responses claim Bruner, Goodnow, and Austin (1962).

Vinacke (1951) summarizes five methods of measurement that have been used: interview-questionnaire, performance, introspection, learning, and problem solving.

Introspection, learning and problem solving have been effectively used with adults. The introspective technique requires the individual to verbalize how he discovered an answer, and therefore requires an attitude of self-awareness that a child usually has not yet acquired. The learning method involves being taught a principle and then using it to solve or explain a similar but different situation. This could be used with children, but is not useful in situations where the purpose of the study is to ascertain how the child performs spontaneously. The problem-solving method is similar to the learning method except that there is no training period. The individual is presented with stimuli and asked to determine the principle they exemplify. This method would not be very successful with children because it would require them to apply thinking strategies not usually available to them.

The interview-questionnaire and performance methods have been used with children. Through the interview-questionnaire the tester can solicit reasons for answers from the child, fit the questions to the child's type of answers, and still retain a standardized type of approach and standardized questions. It allows the child freedom to think in any style he chooses and provides the examiner with valuable additional data to the answers. However, the data may be quite subjective. The performance method requires the child to do something, such as put things together, or mark things that don't belong, after having observed a demonstration or having performed a sample exercise. A drawback to this method is that it is hard to determine whether the child has learned a stimulus-response reaction or is doing logical thinking. The performance method and interview-questionnaire method can be used separately or in combination.

Many of the studies quoted earlier in this chapter have used the performance method. Free classification of objects, pictures or words provided the data for Blackford (1970), Vygotsky (1934), Bruner, Olver, and Greenfield (1966), Denney (1972), Sigel, I.E. (1954, 1967, 1971), Thompson (1941), and Wei, Lavatelli, and Jones (1971). Choosing an object to match a key object was used by Birch and Bortner (1966). Matrix completions were used by Bruner, Olver, and Greenfield (1966), Mackay, Fraser and Ross (1970), and Parker, Rieff and Sperr (1971). Intersection completions were used by Findlay (1971), Parker and Halbrook (1969), and Parker and Day (1971).

Piaget and Inhelder (1964) used the interview-questionnaire method. A situation requiring logical operations was presented and the child was requested to state a solution to the situation and to give a verbal justification for the solution.

Rawson (1969) adapted a combined performance and interview-questionnaire method for her study. A situation requiring a logical operation to be performed in order to arrive at the solution was presented. The child was then asked to state a solution verbally, to justify his solution verbally, and finally to demonstrate the solution he had stated.

Interpreting the verbal answers children give is complicated by the language they use. Roger Brown (1958) believes children use the vocabulary of adults without the understanding of adults. Bruner, Goodnow, and Austin (1962, p. 60) quote a study by Bouthilet which suggests that the actual performance of creative problem solvers may run ahead of their ability to state verbal justifications. Therefore it would seem that a combination of the performance and interview-questionnaire methods would produce the most satisfactory results when measuring logical operations in children.

Summary

Classifying is essential to human knowledge and mental activity because it reduces the amount of information the mind is required to store and use. It is a logical operation that requires the identifying and abstracting of common properties from a set of things, and grouping them to form a systematic arrangement or organization. All classifications are arbitrarily established by societies to suit their needs and convenience, and, therefore, need to be learned.

There are basically three types of classifications: simple, additive and multiplicative. The types of criteria children identify and abstract in order to make these classifications are perceptual (e.g., size, color, shape), functional (e.g., use), and conceptual (e.g., conventional names). The amount of use made of each type of criteria changes as the children grow older from mostly perceptual to mostly functional to mostly conceptual. In addition, the quantity of different types of criteria that children can apply to one set of objects increases as they grow older.

Several methods for measuring classificatory behavior were described. The two most successfully used with children are the performance method and the interview-questionnaire method, singly or in combination.

II. THEORIES ABOUT CLASSIFICATORY DEVELOPMENT

There has been and continues to be a great deal of debate about how children and adults perform logical thinking tasks and the differences between them. One of the observable differences between child and adult thinking is their method of approaching reality. The child is egocentric; he believes he is the center of all events. The adult is objective; he believes he is only one of many participants in all events. Other differences are their views of the world and their uses of language. The child believes all things are animate, while the adult distinguishes between non-living things that are inanimate and living things that are animate. When the child talks he expresses his inner thoughts and does not need another person to listen to him, whereas the adult talks to communicate with another person.

Some psychologists and philosophers have concerned themselves with the reasons for the differences between child and adult thinking; that is, whether children do logical thinking in a different way than adults, or whether they do it more poorly than adults. Whatever the reasons for the differences, however, a difference exists. How people move from the child level to the adult level is another issue with which many psychologists, philosophers, and educators concern themselves. Research examining both of these issues will be reviewed in this section.

Some of the Differences Between Child and Adult Thinking

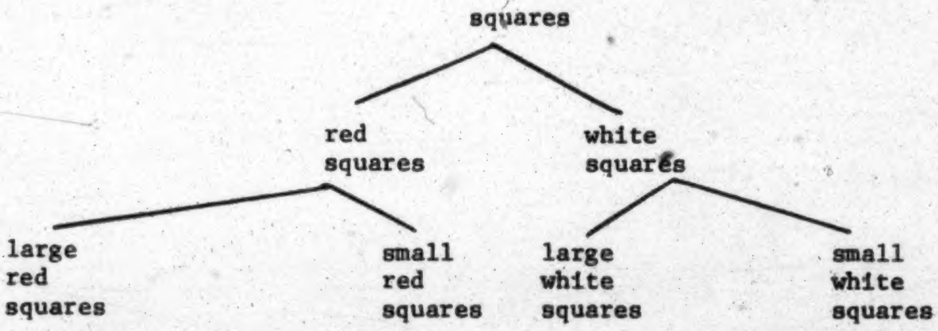
Several theories about the change process from child to adult thinking will be reviewed. Issues which have been considered are whether the change is in discrete stages or is continuous; whether it is sequential or not sequential; whether language has an interacting effect or develops independently; and the effects of maturation and instruction.

Inhelder and Piaget (1964) postulate a developmental sequence which occurs in discrete stages independently of language, due in part to biological development. They believe that logical operations develop after perception, language, and simple relations. After their appearance they then co-develop with these other functions. The transition between stages is governed by the dominance of certain actions, beginning of hindsight and anticipation, and reversibility.

Piaget's theory proposes that this observation, that as children get older there is an improvement in their classificatory performance, is evidence that classification is a developmental logical operation. He proposes that there is a cumulative growth from one stage to the next which means that an older child can classify using any of the criteria, perceptual, functional, or conceptual, depending upon the individual and the circumstances; but the younger children can usually only classify using criteria characteristic of their stage, such as perceptual. Also he proposes that the behaviors children of different ages exhibit are evidence of a development from a concrete thinking to an abstract thinking level.

Inhelder and Piaget believe there is a pre-logical or pre-operational stage during which the child is not able to classify. During this time he is capable of forming graphic and non-graphic collections (i.e., puts real objects together with no real connection between the items). However, they believe that true classifying develops out of these actions.

During the in-between stage, concrete operations, the child is able to classify but only on the basis of perceptual criteria. He reasons, but without stability in his concepts. For example, the child may say that when he puts red squares and red circles together, that all the objects in the group are red. However, he may then not say that some of the objects are squares. He can form simple hierarchical classifications. For example, a collection of objects can be subdivided as follows:



Four to seven of the ten characteristics of true classification are usually present at this stage (see Appendix A) but the child still lacks reversibility and the coordination of intension and extension.

Reversibility takes two forms: inversion (negation), -A is the inverse of A, and reciprocity, 1/A is the reciprocal of A. An example of negation in classification is given by Ginsberg and Opper (1969, p. 131). If a set of yellow primulas is combined with flowers that are not yellow primulas, then there is no group of yellow primulas, (A + (-A) = 0); however, if the flowers that are not yellow primulas are taken away, the group of yellow primulas remains. An example of reciprocity is also given. If there is a group of red squares and white squares, and the white squares are removed, the group of red and white squares would not exist (A x 1/A = 0) as a group. To obtain it again, the group of white squares would have to be combined with the red squares. The child comprehends reversibility when he realizes that an action that is performed can be undone by an opposite action, and the original state can be re-obtained by performing the original action again.

Classes have intensional and extensional properties by which the members of a class are related to one another, and to the other classes in a total grouping. Intension is the set of characteristics common to the members of a class (e.g., redness, squareness). Extension is the set of members themselves (e.g., red squares). These definitions have been developed by Inhelder and Piaget (1964, p. 98). Rawson states that the greater the intension the smaller the extension of a class (1968, p. 134). For example, if the intensional properties are squareness and redness, the class so defined (extension) is greater than if the intensional properties are squareness, redness, smallness, smoothness, and glass. The two properties, intension and extension, cannot be differentiated very well, although each can be observed.

The final stage described by Inhelder and Piaget is called the stage of formal operations. At this stage the child is able to coordinate intension and extension, and understands reversibility. He is capable of true classification.

Inhelder and Piaget have suggested that the ages of children at each of these stages are approximately birth to seven years for pre-operational, seven to eleven years for concrete operational, and eleven to fifteen years for formal operational. They believe these stages develop spontaneously over time through the processes of organization and adaptation.

Ginsburg and Opper (1969, pp. 18-19) define organization as the tendency to integrate structures, which may be physical or psychological, into higher-order or intellectual systems or structures. Examples of higher-order or intellectual structures are looking at objects and grasping them with a hand, and looking at objects and grouping them.

Adaptation is defined by Ginsburg and Opper (1969, pp. 18-19) as an interaction or exchange between a person and his environment and involves assimilation and accommodation. To intellectually assimilate, the person incorporates features of external reality into his own psychological structures. To intellectually accommodate, the person modifies his psychological structures to meet the pressures of the environment. Examples are the child who can group objects by color observing that they can also be grouped by shape, or the child who recognizes birds, dogs, and cats, learning that these are all animals.

Although Inhelder and Piaget explain the development from stage to stage without referring to factors other than maturation, such as perception, learning, and language, they do believe these factors play a part in the realization of operational thinking and behavior. That is, no one factor completely determines the total process. For this reason, Inhelder and Piaget believe instruction should parallel development, but it cannot speed it up.

Piaget's theories are supported in part by many authors. Parker and Hallbrook (1969) observed multiple classification in subjects placed in Kindergarten to Grade three, and concur with Piaget that the skill is developmental because performance improved with grade level. Bruner and Olver (1963) studied Grade one, four, and six students on equivalence transformations and found that grouping strategies were developmental and the language used to explain was developmental. Whyte (1970) compared students of low to average intelligence, aged twenty to twenty-two years, on addition and multiplication of classes, additive composition, and hierarchical classification, and found both groups followed the sequence established by Piaget, and seemed to fixate at certain stages. Similar results were found by Lovell, Mitchell and Everett (1962) using five to ten-year-old normal children and nine to fifteen-year-old below normal children. Wei, Lavatelli and Jones (1971) studied shifting of criteria, use of real objects, inclusion, and multiplication, with culturally deprived and middle class youngsters who were in Kindergarten and Grade two. They support Piaget's sequence and his equilibration theory.

Vinacke (1954) is one of many authors who does not believe in a theory of discrete stages, but in continuous development. He believes there is a continuous and cumulative change in thinking with increasing age. Changes that take place are from simple to complex concepts, that is from understanding concepts about the neighborhood to the world community; from diffuse to differentiated concepts, that is from understanding some interrelationships to understanding many social roles and attitudes; from egocentricity to objectivity, that is from thinking of himself as the center of other peoples' experiences to thinking of his experiences as distinct from others' experiences; from concrete to abstract, that is from thinking of perceived or known things, such as Dad's car, to thinking of things as members of a class, such as a car; from variable to stable, that is a word such as cat being applied to any four-legged animal, to cat being applied only to a particular four-legged animal, a cat; from inconsistent to consistent, that is from believing a perceptual feature is overly important (e.g., height or space indicating bigness), to a perceptual feature being considered in relation to other factors. Vinacke believes the change is not due primarily to either mental age or vocabulary, but to increasing age, and therefore to maturation and experience.

There are some authors who believe neither in Piaget's theory of sequential development, nor in Vinacke's theory of continuous development. They believe there is no predictable sequential development of logical operations. Denney (1972) attempted to replicate Inhelder and Piaget's findings on developmental stages with children aged two, four, six, eight, twelve and sixteen. Order was not significant. Tests used were free classifying and verbal-label classifying. Kofsky (1966) tested the order of difficulty of classification tasks and the cumulative effect with subjects aged four to nine years. Although the older ones did better than the younger ones, regular stages were not clearly indicated, and the order of learning was not as Piaget cited. Piaget and Inhelder's (1964) model of the steps by which children learn class inclusion was:

1. resemblance sorting
2. consistent sorting
3. exhaustive sorting
4. conservation
5. multiple class membership
6. horizontal classification
7. hierarchical classification

Individuals seem to vary in the sequence of mastery of cognitive tasks, and the steps by which they master particular cognitive tasks. In Kofsky's study a developmental trend seemed to be present but a specific sequence of mastery of skills was not present.

Findlay (1971) questioned Inhelder and Piaget's claim that partial multiplication of classes develops later than complete multiplication of classes on the basis that Inhelder and Piaget tested each type differently. Inhelder and Piaget used free choice for one and finite choice for the other. Findlay found that the type of choice significantly affects the performance of subjects, i.e., they do better on finite choice than on free choice.

Braine (1959) examined Piaget's theories of length and order concepts and agreed with the stages but not with the age of understanding. He thought the age of understanding occurred earlier. Ausubel (1964) believes the importance of the developmental concept is the sequence, not the age of occurrence, because the speed of development can be affected by environmental factors. However, he believes training can accelerate the process only within the limits imposed by the stage of operations of the child. Other authors believe that the operations are trainable, and there are no limits to restrict the speed of development from a less to more competent performance.

Kohnstamm (1967) attempted to teach five-year-olds to answer questions on inclusion relations. He found that it was possible for children to perform an operation before reaching the stage of development cited by Piaget (1964) if they are trained with a particular method and mode. He tried three types of training modes: verbal, pictorial, and objects-plus-pictures-plus-verbal. The last mode was most effective and caused retained learning of an operation earlier than Piaget cited. The method used in all cases was to explain and give correct answers, and use counting to teach that all is greater than any parts.

Other such studies have been done. However some attempts at training in classification seem to support the Piagetian theory in general. Parker, Rieff, and Sperr (1971) attempted to teach multiple classification to four and a half, six, and seven and a half-year-old children and found it to be more effective with the older children. I. Sigel (1971) attempted to teach classifying objects by more than color and use, and to teach combining groups, and found within eight months that there was little difference in performance between the trained and not trained. Taba and Freeman (1964-65) attempted to teach thought processes using sequential lessons that parallel the evolutionary sequence and found the sequence to be essential. If the sequence was followed, more students could achieve higher levels of cognitive operation. Concept formation followed the sequence:

1. enumeration of concrete items
2. grouping the items
3. labelling or classifications

According to Furth (1969) Piaget believes language is not a necessary element of operational thinking. Piaget believes children can express what they think. Errors will be due to logical inadequacy not linguistic incompetence. Origins of operations of logic are not in language and language is not the central factor in their development state Inhelder and Piaget (1964).

In Thinking Without Language Furth (1966) provides evidence from studies comparing deaf students and hearing students which seems to corroborate Piaget's theory. A comparison of deaf with hearing subjects on logical classification was made with two samples, college level and non-college level adults aged twenty to fifty years. The materials used were forty-eight cards with two geometric figures per card which were to be grouped into categories based on the criteria of shape, color, similarities (conjunction), and differences (disjunction). The results with both samples were similar, and the results between the deaf and hearing groups were similar. Furth concludes that thinking can be with symbols of a language system that is verbal, or without these symbols. Therefore the relation between language and thinking is not essential. With no verbal symbolic system, thinking can still take place. The performance in thinking by the deaf was unaffected by the absence of verbal language if other experience was equal. Furth suggests teaching methods should teach thinking through non-verbal methods.

Silverman (1967) found that deaf and hearing children with similar reading achievement performed classifications with similar competence and used similar criteria. His study was conducted with students aged seven to fourteen years and measured the amount of use made of three types of criteria: superordinate, functional and associative. He believes deficiencies in categorization behavior may contribute to deficient language performance in deaf children. As was implied by Furth's study, Silverman's study implies that language is more influenced by thinking skills than vice versa.

Vygotsky (1962) believes that language plays a key role in the classification process. He bases this on his theory that thought and language combine at about the age of two years, each having developed independently prior to this, to form intellectual language or verbal thought. He believes thought and language are interrelated from age two onwards and one cannot develop without the other. Concepts are formed through intellectual operations guided by the use of words.

Britton (1970) supports the Vygotsky view. He believes that there is organization in speech and organization in thought which is interrelated. First the child speaks language which is organized without understanding; secondly, the child speaks language and understands; thirdly, he thinks first, then speaks; fourthly, he can think more than his speech can express. Britton, like Vygotsky, believes that development is influenced by maturation and instruction, and that instruction makes the child conscious of things he does unconsciously.

Summary

It seems that all authors agree that logical operations are developmental. Some believe the development occurs in stages and others believe it is continuous. Some believe there is a particular sequence of skill attainment, and others believe there is no particular sequence. The role played by the factors maturation, language, and instruction, is viewed in many different ways; however, all authors acknowledge that these factors are involved in the performance of logical operations to a greater or lesser degree.

Reasons for the Differences Between Child and Adult Thinking

A change in ability to perform classificatory operations as children grow older has been documented in many studies. Shantz (1967) investigated the relationship of multiplication of classes, logical relations, and spatial relations with children of seven, nine and eleven years and found with an increase in age there was an increase in performance. The older children were able to answer more questions correctly than the younger children. Bruner, Olver, and Greenfield (1966, pp. 154-167) found the ability to understand multiplicative groupings improves with age. Studies which were reviewed in the section on criteria showed that performance with both perceptual and conceptual criteria improves with age. In addition, it was found that relatively more use was made of perceptual criteria by young subjects, and of conceptual criteria by older subjects.

Piaget believes that children think differently than adults. He believes the reason the child's classificatory behavior is different to an adult's is because children can't coordinate extension and intension, and can't differentiate logical (mental operations) and sub-logical (perceptual actions) operations. Classification is logical when a child coordinates bringing together objects, and applying criteria within a group to regroup. Classification is sub-logical when a child brings together objects and believes their proximity to one another constitutes their "groupness". In the first instance the child can apply a common criteria to join objects, and in the second he cannot.

Roger Brown (1958) believes that the difference between child and adult thinking is not that the child cannot do abstract thinking, but that he cannot differentiate between abstract and concrete terms. For example, he may call all men daddy, or call all individual fruits, fruit.

Further to this was a study done by Polermo and Jenkins (1963) with children of Grade four age up to college age. The subjects were given the Kent-Rosanoff free-association test of 100 words followed by a list of 100 stimulus words. They were to give their first response to the stimulus word using only one word. The frequency of superordinate responses was tabulated. Results showed that from Grade four to Grade six, concrete responses decreased and abstract increased; from Grade six to adult, responses became more concrete; therefore, Grade six subjects gave the most abstract responses. It seems that mature and immature subjects use concrete responses, but as Brown states, the difference is that the mature subject uses the response correctly all of the time, whereas the immature subject does so only by chance, if at all.

Vinacke (1951, 1954) believes that there is no difference between the style of child and adult reasoning. In a research review of many authors he summarizes the process of logical thinking in children that Piaget and others postulate to be perception, then abstraction, then generalization. This process allows them to perform only concrete thinking. The process in the adult is perception, then abstraction and generalization together. This means that at this stage grouping and separating are two aspects of the same process, therefore concrete and abstract thinking is possible. Vinacke disagrees with this theory because he believes the processes of abstraction and generalization cannot operate in isolation and that both children and adults can do both. The observable difference between child and adult reasoning he believes is one of degree not of kind, due to experience. Experience includes training and environmental influence.

Kagan (1964, 1965) believes that children of the same or different ages think differently, but he attributes this to differences in thinking styles rather than to differences in cognitive development. Through a series of studies he has observed the behaviors of reflective and impulsive problem solvers, and analytic and non-analytic attitudes. He believes certain children prefer to think in one of these ways more than another, independent of their knowledge, vocabulary and climate of the testing situation. Performance would depend more on how the task was suited to the child's thinking style than to the child's cognitive stage of development.

Summary

In this section, four major reasons why children do not do logical thinking like adults are presented. They cannot differentiate abstract and concrete terms and apply them appropriately. They cannot coordinate intensional and extensional properties. They lack experience, and they cannot apply thinking styles to problems effectively.

III. RELATIONSHIP OF CLASSIFICATION ABILITY TO READING ACHIEVEMENT

The purpose of this section is to discuss whether there is a relationship between classification ability and reading achievement and if so the kind of relationship. The use of classifying in reading, and the value of knowing about the relationship of classification ability and reading achievement will also be discussed.

Is There a Relationship Between Classification Ability and Reading Achievement?

D. H. Russell (1965) states that behavior which involves the apprehension (understanding) of events or objects such as printed symbols may be profitably conceived as a categorizing activity, whether perceptual or conceptual. It follows, therefore, that reading, identification and comprehension, probably involves classification. Identification involves apprehension of letters or words in the sense of recognition (i.e., letter and word labels). Comprehension involves apprehension of concepts associated with words, such as word and phrase meanings.

To form a concept is to establish a categorization. This is because a concept is an organizing system which serves to bring pertinent features of past experience to bear upon a present stimulus object according to Vinacke (1954, p. 529). For example, having seen cats, a child would be able to recognize a new cat as a cat. Therefore a concept seems to be a particular type of classification which is a mental representation for a set of impressions, feelings or percepts.

A study by J. S. Braun (1963) on the relation between concept formation ability and reading achievement at three developmental levels is applicable to this topic. The subjects in the study were all boys. There were fifty in Grade three, fifty in Grade five, and thirty-nine in Grade seven. Braun devised a concept formation ability test (CFA) by adapting an instrument developed by H. G. Reed, which was administered individually to the subjects. The CFA score was correlated with the comprehension reading score obtained from Gates Advanced Primary Reading Test (Grade three), Gates Reading Survey (Grade five and seven), and Iowa Achievement Test (Grade seven). The CFA test consisted of twenty concepts with six cards per concept. Out of four words on each of the six cards the child was to choose those six words which had something in common and tell what the concept was. She found that the subjects' concept formation scores were highly related to reading. Those with poor concept formation scores were underachieving readers. Braun speculates that perhaps children who don't read beyond the primary level can't function abstractly enough. Different mental abilities are involved in reading at different grade levels, going from primarily concrete material in the lower grades to primarily abstract material in the higher grades.

Jan-Tausch (1962) examined concrete thinking as a factor in reading comprehension with 170 Grade four, five, six, and seven students, with half of the subjects male and half female at each grade level. The tests used were the California Reading Test Form CC and Form AA, for a reading comprehension score, and part of the

Goldstein-Scheerer battery of abstract and concrete thinking tests (Color - Form Sorting Test; Cube Test). Jan-Tausch found that abstract thinkers are also advanced readers and concrete thinkers are retarded readers, with a significant difference existing between the abstract and concrete behavior of the advanced and retarded readers. "It would seem that a child's learning process in reading . . . follows closely his freedom from the limitations of concrete thinking (Jan-Tausch, 1962)." The relationship is more significant at higher grades, perhaps because reading there tends to be more abstract.

The evidence gathered in these studies point out that there is a relationship between classification ability and reading achievement, at least insofar as the classification process is applied to concept formation, and a possible change in relationship over grade levels is evident.

Rawson (1969) and Smith (1971) provide two different explanations of a possible relationship between reading comprehension and classification ability.

Frank Smith (1971) states some very specific categorizations that in his opinion need to be constructed by the reader in order to decode and comprehend print; in fact, he believes "every aspect of reading can be seen as a process of categorization (p. 76)." For example: (1) letter identification: a and A belong to a category called a; (2) word identification: cat belongs to a particular sequence of sounds and refers to a particular type of animal; (3)

word meaning: individuals organize their categories by interest, experience and set (e.g., *snow* for skiers, desert nomads, Eskimos). To read for understanding Smith claims certain processes of learning word meanings must be followed in sequence. Information obtained through perception is organized into categories and relationships that can be used to identify, interpret, and predict. Each category can be defined by rules and has internal similarities. Between categories are significant differences, some of which are mutually exclusive, and some of which are hierarchically related. Learning from a cognitive point of view involves: establishment of new categories, development of relations among categories, refinement of rules for the allocation of events to categories. Once certain categories have been established by the mind, these become organizations that the individual imposes upon incoming information on the basis of semantic features. The child may be taught to recognize *to*, *too* and *two*. Each word represents a new category for meaning, and all are related because of their auditory similarity. The rules which must be learned to place these words in categories are based on explaining how each one functions differently from the others in a sentence. The child then recognizes which is which on the basis of syntactic and semantic features used; for example, in the phrases: _______the lake, _______ apples, and John went ______.

The kind of relationship that Rawson (1965) postulates between classification ability and reading comprehension is a facilitative relationship. She describes the relationship of logical thinking and reading comprehension as interdependence. Both are developmental and both change from a primitive to a mature level in a sequence of stages, as a result of the interaction of the individual with his environment.

Logical operations underly comprehension. For example, reading comprehension depends upon an individual's ability to formulate mature concepts. Once an operation is acquired, such as that of abstraction or quantification, it can be applied to many different situations and contexts.

Logical relations underly reading comprehension. At the first or concrete level are causal relations, and at the second or abstract level are implicative relations. Logical classes understanding is exhibited by correct use of quantifiers: some, every, all, etc. Both of the operations of logical classes and relations are aspects of classificatory behavior. Therefore, it seems that classificatory competence facilitates reading comprehension competence.

Using Classification While Reading

To use classification in reading, Rawson (1965) suggests:

1. hierarchical classification
    a. to develop meaning
        e.g. primitive level - object names;
        mature level - object names and relations
    b. to develop main ideas
        e.g., level 1 - properties of objects
        level 2 - similarities and differences
        level 3 - hierarchical system properties

2. multiplicative classification
    a. to understand embedded clauses
    b. to understand complex sentences
    c. to understand complete articles
    d. to understand sentences with two qualifiers (e.g., The ones who are _early_ and _in line_ will be able to see the play.)
    e. to understand compound sentences (i.e., conjunction, disjunction, and negation)
3. all classification types
    a. to make outline formats

Chomsky (1965) illustrates how generative grammar is based on categories and subcategories (S, NP, VP) which the child understands intuitively. The child internalizes this system of rules and this is part of the experience he brings to the printed page, a very specific kind of classificatory attitude and specific types of classifications.

Paragraph organization say Bond and Wagner (1966) is a basic element of reading comprehension. Interrelationships among paragraphs is a basic comprehension ability for total selections. Both of these are classificatory behaviors.

Thinking in reading involves using symbols and an early ability which needs to be developed to use symbols is classification according to Rawson (1965). Stauffer (1969) explains by saying words are not concepts but symbols of concepts; therefore, a word is an act of generalization; therefore, a concept is an act of generalization. A concept is an act of generalization because, says Stauffer (p.374): it is established out of a set of constant rules about differing perceptions. To develop concepts (e.g., number, quantity, time, historical, geographical) a person must use the functions of logical memory, abstraction, and seeing likenesses and differences, all of which are classificatory behaviors. To comprehend concepts would require using these same operations.

Words are themselves classifications, and the means for building up categories, states Britton (1970, p. 41). Hayakawa (1949) says to give something a name requires using classificatory operations, and a word represents many objects or ideas, not just one. For example, the word 'square' refers to large and small squares, red and white squares, outlined and cut-out squares. There is not just one but many different objects that are labelled 'square'.

The whole process of problem solving (i.e., see problem, define it, state hypotheses, test, conclude) can be applied to reading, claims Stauffer (1969). The form it takes in reading is: set a purpose, define purpose while reading and state hypotheses, judge, and conclude. Stauffer believes the reader's purpose is determined by his level of conceptual development and his cognitive functioning. Spache (1969) believes reading comprehension should be taught as a thinking process and quotes several studies to support his stand.

Eash (1967) lists five areas of cognitive abilities that can be developed through reading, of which one is discriminating. This involves detecting, differentiating, classifying, relating and seeing organization. It seems that as well as using classificatory behavior to aid reading comprehension, reading can be used to develop thinking skills including classifying.

Value of Knowing about the Relationship of Classification and Reading

Just how important the relationship between reading comprehension and classification is has been examined by several studies.

Bruner and Olver's test of grouping discriminately different things together was administered to a number of grade four, five and six students of average ability in a study conducted by Custenborder (1968). Responses were measured as thematic, complexive or superordinate. The findings revealed that the ability to classify superordinately was not significantly related to reading achievement or retardation. A difference was found, however, in the type of classification base used. More retarded readers used a perceptible feature base (perceptual criteria such as size, shape, color), while more achieving readers used a functional feature base (functional criteria such as use, manner of use).

Wickens (1963) examined the ability of good and poor readers to abstract. The purpose of Wicken's study was to examine whether abstraction ability is related to reading. A sample of fifty Grade four students of average intelligence was selected. Half of them were good readers, and half of them poor readers. The tests included perceptual tests (Wepman auditory, Raven's Colored Progressive

Matrices), and tests on sorting and classifying (Primary Mental Abilities, Wisc Similarities Subtest, Shure Wepman Concept Shift Test, and Object Sorting Test). The results indicated that good readers did significantly better than poor readers abstracting, performing tests of abstraction, and verbalizing the categorizing principles arising from abstraction. Several implications of the study were stated: that testing reading aptitude could be done with tests that measure the ability to classify, or categorize, and abstract concepts, that the testing instruments be used to provide insight into the difficulties of the poor readers, that the tests be used to understand language behavior since language is in categories, and that teaching methods and materials be developed that would (a) develop the ability to abstract, classify, form or attain concepts, apply precise language to express concepts formed, and (b) encompass objects of the environment.

Rediger (1970) examined verbal hierarchical classification in disabled and able male readers in Grade four and six and found classification ability was developmental, and that good readers could perform the task better than poor readers. The findings were that all able readers did significantly better than disabled readers; that both Grade four and Grade six able readers did significantly better than Grade six disabled readers.

There seems to be a close relationship between classificatory behavior and reading comprehension. Reading involves logical operations in a particular way because the raw material of reading is symbolic data. Therefore, although an individual is capable of performing logical operations with and upon other kinds of data that is concrete or perceptual, to do so with and upon the symbolic data of reading may be a new problem for him. The importance of being able to perform logical operations with the symbolic data of reading is especially important in the area of reading comprehension. Once the print concepts have been formed and attained, the child faces the challenge of manipulating them. This involves the many complex processes of logical operations.

Logical operations are not dependent on reading, but reading is dependent upon logical operations. Classification is basic to both processes. Therefore, the relation of the classificatory operation to reading is an important one. It is a necessary means for reading acquisition (beginning readers), and in a different way, a necessary means for advanced reading comprehension (mature readers).

Summary

Studies by Braun (1963) and Jan-Tausch (1962), were described in order to illustrate that there is a relationship between classification ability and reading comprehension achievement scores. A possible change in the relationship over the grade levels due to the change from concrete to abstract thinking as children get older, and to the greater quantity of abstract concepts in books at higher grade levels, was also indicated.

Possible relationships between classification ability and reading comprehension have been described by Frank Smith (1971) and

Rawson (1965). Smith believes that every aspect of reading is actually a process of categorization. Rawson believes that classification ability facilitates reading comprehension.

Applications of classification ability while reading are very numerous.

The relationship between reading comprehension and classification has been found to be very significant. That is, good readers score higher on classificatory tasks than poor readers. Studies which established these results were done by Wickens (1963), Rediger (1970), J. S. Braun (1963), Jan-Tausch (1962), and Rawson (1969).

IV. SUMMARY

Classifying is a human invention designed to simplify information storage and retrieval by the brain. Sets of objects, events, people or things are systematically grouped together and given a common symbolic representation, for example, a word. There are at least three basic types of classifications and a continuum of criteria ranging from perceptual to conceptual provide the base upon which these classifications are formed. Of five most frequently used methods for measuring classificatory behavior, two have been used with children successfully.

There is a difference between child and adult thinking, and the development from one type to the other has been described in several ways. Piaget (1964) and others believe the change is sequential and either in stages or continuous. Others believe the sequence and speed of acquisition varies from individual to individual and can be affected by training in certain skills. The influence of language, maturation, experience, and instruction upon this development has not been well determined. These factors may contribute to the differences between child and adult thinking to a greater or lesser degree. Piaget (1964) believes maturation to be most important; Brown (1958) believes language to be most important; Vinacke (1951, 1954) believes experience to be most important; and Kagan (1964, 1965) believes instruction to be most important.

A positive relationship between classification ability and reading comprehension has been verified by many studies. The exact nature of the relationship, however, is a matter of speculation. Studies by Smith (1971) and Rawson (1969) are among those which have tried to determine and describe the relationship. The value of classification ability to reading with understanding, and to utilizing information obtained by reading has been illustrated.

The need for a more precise understanding of the relationship between reading comprehension and classification ability has been established in this research of literature.

CHAPTER III

THE DESIGN OF THE STUDY

I. INTRODUCTION

The purpose of this chapter is to describe the design of the study. A description of the sample is followed by a description of the tests used. Modifications made upon the original Rawson experimental tests and the scoring procedures are described and explained. A description of the pilot study and the statistical procedures used to analyse the data conclude the chapter.

II. THE SAMPLE

The sample for this study was selected from the Grade four, five and six populations of one school within the Edmonton Public School System. The populations consisted of eighty-three Grade four, seventy-nine Grade five, and seventy-nine Grade six students. Subjects who did not have Lorge Thorndike I.Q. scores recorded within the preceding two years, and/or Canadian Test of Basic Skills reading scores recorded within the preceding year, on the cumulative record cards, were eliminated from the population. The Lorge Thorndike Test had been administered to the resulting Grade four population in May, 1972, the Grade five in February, 1971, and the Grade six in February, 1973. All students had a Canadian Test of Basic Skills set of scores for either June, 1972, or September, 1972.

From the selected population, fifteen students were chosen from each grade level by employing a table of random numbers.

The reason for choosing students at the Grade four, five, and six levels was to attempt to examine the results of the classification section of the study done by Rawson in 1969 with Grade four students, and to examine classification performance over these particular grade levels.

Rawson had chosen Grade four students for her study because the children at this level could be expected to have a reasonable competency in the decoding aspect of reading and would not have word recognition errors hampering their reading comprehension. Also, they would have been operating at the level of concrete cognitive operations long enough to be consolidating the intellectual operations characteristic of this phase of development, in preparation for the major advances of early adolescence. These assumptions of Rawson have been accepted for this study as well, and for all of the subjects from grades four to six.

Information about each member of the sample was recorded. Sex, age, and verbal I.Q., non-verbal I.Q., reading vocabulary and reading comprehension scores were obtained from the cumulative record cards. Scores on the print and concrete classification test batteries were obtained by individual testing.

III. STANDARDIZED TEST INSTRUMENTS

Lorge-Thorndike Intelligence Test

Verbal and Non-Verbal Batteries, Level 3, Form A.

The purpose of the Lorge Thorndike tests according to Buros (1959) is to measure abstract intelligence which is the ability to work with ideas and relationships among ideas. The particular cognitive tasks sampled by the test are: (a) dealing with abstract and general concepts, (b) interpretation and use of symbols, (c) dealing with relationships among concepts and symbols, (d) flexibility in the organization of concepts and symbols, (e) utilizing one's experience in new patterns, (f) utilizing 'power' rather than 'speed' in working with abstract materials. The tests measure reasoning ability more than mental capacity.

The level 3, form A test is designed to be used in Grades four to six. There are three scores: verbal, non-verbal, and composite. The mean I.Q. is 100 and the standard deviation is sixteen.

Norms for these tests were standardized on a population of 136,000 in 44 communities in 22 states of the United States. The communities were selected in order that an appropriate stratified sample of American communities based on socio-economic factors were represented. The latest standardization was made in 1963 and a multi-level format booklet was developed.

Odd-even reliability scores were between .88 and .94. Alternate form correlations were .76 to .90 at all levels. Validity studies indicated positive correlations between the results on this test and school achievement.

The tests are considered to be widely used, well constructed, well presented, well designed, and quite sound (Buros, 1959, 1972).

Canadian Tests of Basic Skills

Form 1, Multi-Level Edition for Grades 3 - 8

The Canadian Tests of Basic Skills battery is a Canadian adaptation of the Iowa Tests of Basic Skills battery. The purpose of the battery is to evaluate generalized educational skills and abilities, not content achievement. The skill areas dealt with are vocabulary, reading comprehension, language, work study skills, and arithmetic. The vocabulary test measures noun, verb and adjective meanings. The reading comprehension test measures the ability to grasp details, the ability to determine purposes, the ability to analyze organization, and the ability to evaluate a reading selection.

National and local norms are available. All norms are expressed as grade equivalents, and percentiles are provided for within grade comparisons. Separate norms are provided for each subtest, and all norms are listed for the beginning, middle and end of the year. Canadian norms were obtained in 1966 with 30,000 children. A stratified random sample was made of children, who spoke English as their mother tongue, from 225 English-speaking schools across Canada.

Reliability coefficients range from .84 to .96 for the major tests and .70 to .93 for the subtests. The composite reliabilities for the whole test range from .97 to .98 for the different grades.

These tests seem to be well respected because of curricular validity, careful and good construction and design, and the clarity of the materials.

IV. THE EXPERIMENTAL TEST INSTRUMENTS

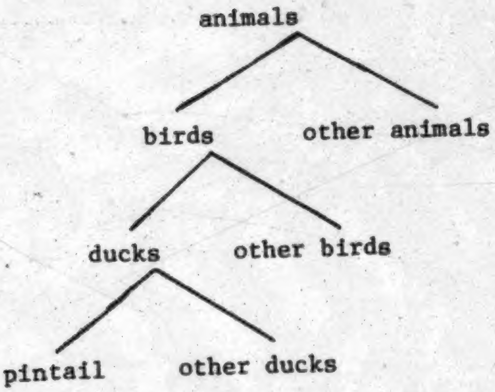
The experimental tests used in this study were derived from Rawson's Study of the Relationship and Development of Reading and Cognition (1969). Two batteries of classification tests were used. One is called the print battery and will be symbolized by P. The other is called the concrete battery and will be symbolized by C.

The general format of both batteries was constructed to first present a stimulus situation, and then to present questions about the situation which involved classificatory operations. The stimulus situation for the print battery was a story to be read silently; the stimulus situation for the concrete battery was a collection of objects to be manipulated. An inventory listing the materials used appears in Appendix B.

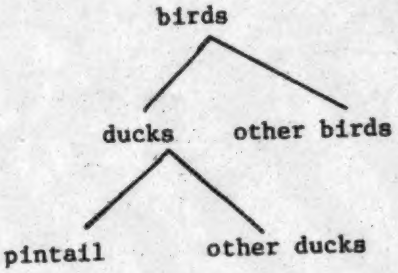
The questions presented for both batteries were of three main types: class inclusion relations, predicates, and multiplicative classes. A question of the class inclusion relations type would require the student to recognize and compare subordinate and superordinate groups. For example, are there more red objects in a group of red circles and red squares, or are there more squares? A question of the predicate type would require the student to recognize relations between members of a group and the group itself. For example, are the ducks who arrive early, early-arriving birds? A question of the multiplicative classes type would require the student to abstract one distinct property from each of at least two other groups, and to combine these properties to form a new group. For example, what would belong to both small squares and red objects? The questions were designed to examine classificatory cognitive operations at the concrete level of intellectual development as defined by Piaget (1964). A detailed symbolic description of the classificatory operations and the test questions in both batteries appears in Appendix C.

Each type of question was handled in a separate subtest within the total battery. The total number of items was twenty-five with a distribution per subtest of sixteen class inclusion items, three predicate items, and six multiplicative items. The number of items per subtest used in these tests is a change from the Rawson tests in which the total number of items for the concrete battery was nineteen, and the total number of items for the print battery was ten. The distribution per subtest on the Rawson tests was eight items on the concrete class inclusion, four items on the print class inclusion, three items on each of the concrete and print predicate subtests, six items on the concrete multiplicative, and three items on the print multiplicative subtest.

The class inclusion questions on the print battery were changed so that the universe of discourse was birds, rather than animals as in the Rawson tests. This change was made because Rawson stated that students had problems inferring the universe of discourse for ducks as animals. Rawson based her questions on the following type of hierarchy:


animals
birds
other animals
ducks
other birds
pintail
other ducks

In this study the questions were based on the following type of hierarchy:


birds
ducks
other birds
pintail
other ducks

The questions were written in a form that was parallel to Rawson's in order to test the same operations that she had tested.

A complete description of both batteries, including the method of presentation and the scoring criteria, is printed in Appendix D. Because the test items of the two batteries were, in general, constructed as corresponding pairs, a summary illustrating this is printed in Appendix E.

V. VALIDITY AND RELIABILITY OF THE EXPERIMENTAL TESTS

First the validity of the test situation will be described. Then the validity of the test items will be checked by examining the design and the construct validity.

(1) Test Situation Validity

The validity of the test situation for the print battery depends on the comparability of the responses required by the test items in the print test situation with those in the corresponding concrete test situation. The extent of this comparability is illustrated in Appendix E. This method of establishing validity was proposed by Rawson (1969).

The method of establishing validity for the concrete battery proposed by Rawson (1969) will also be accepted for this study, since no change was made in the questions developed by Rawson. The validity of the concrete tests was based on the degree of continuity that had been maintained between the study Rawson did and previous studies in the area of classificatory development.

(2) Test Items Validity

(a) Design of the Test Items - If the items adhered to the rules proposed by Smedslund (1964) in the monograph Concrete Reasoning: A Study of Intellectual Development, they were judged as suitable items for assessing logical operations. Smedslund states that concrete reasoning is achieved if the subject can arrive at a correct conclusion to a logical question after having perceived the initial events and having them removed. To ensure that this occurs Smedslund proposed twelve rules, which were to be used as guidelines in developing test items or tasks and in presenting the tasks to the subjects being assessed. The rules and an explanation of how the items in the concrete and print batteries adhere to them is given below.

> Rule 1 - The tasks should not be solvable on the basis of perceptual processes. This can be ensured if the initial events are absent at the moment of solution.

The stimulus situation is covered prior to the asking of the test questions.

> Rule 2 - The tasks should not be solvable on the basis of readily available hypotheses with a non-logical structure.

The solutions to questions depends upon the ability to mentally note a set of premises and determine a necessary conclusion, and can not be expressions of cause and effect solutions directly available from past experience.

> Rule 3 - Tasks which can be solved on the basis of specific previous information, which may have been available to some children, should be avoided. The solution should not depend upon the child's knowledge.

Before each question the children were informed that the information they would need was in the lay-out or story they had just been shown.

> Rule 4 - Items involving practical skills that are likely to be taught in some environments should be avoided.

The subjects were required to perform operations mentally, which, if taught, would not have been taught in the same environment.

as that of the experimental tests.

> Rule 5 - The possibility of being correct by guessing should be minimized.

To discourage guessing the subject was required to give an explanation for each answer.

> Rule 6 - All information available to the subject should be in the form of perceived events. Verbally communicated hypothetical premises should be avoided.

The objects were perceived and manipulated by the subject during the preliminary questioning. Understanding the words of the story was ensured by careful preliminary questioning. If the subject had difficulty in either instance one of three methods of assistance was provided in the order specified by Smedslund: (1) repetition of question, (2) indirect help, (3) direct help (e.g., naming the objects, or identifying specific words in the story).

> Rule 7 - It must be ensured that the subject actually perceives the relevant events. He must be asked to label them as presented.

The preliminary questions were structured in such a way that all of the data needed for the test questions was pinpointed.

> Rule 8 - It must be ensured that the subject actually remembers the relevant information. He must be asked to recall this information immediately prior to the moment of solution.

The test questions follow immediately after the preliminary questions, and are in a sequence such that each question relates to the preceding ones.

> Rule 9 - Comprehension of the instructions should be ascertained. The subject's usage of terms suspected to be difficult should be checked.

The subject's comprehension was ascertained by his answers to preliminary questions, and the explanations he gave for his answers to the test questions.

> Rule 10 - The required test responses should be so simple that effects of variation in general motor development, verbal fluency, etc., are excluded.

The subject was required to give oral answers and could be assisted during the preliminary questioning. Words which had been used in the preliminary questions were the words which were necessary for the subject to use in answering the test items.

> Rule 11 - There should be no differential reinforcement during the test. Every response should get the same mild, positive reinforcement. This is important in order to maintain the spontaneity and confidence in all subjects and in order to avoid differential learning effects and highly variable guessing behavior.

The examiner attempted to accept all answers as worthwhile and attempted to encourage all subjects by always requiring an explanation for their decisions.

> Rule 12 - The same type of materials should be used throughout the items as far as possible, in order to keep constant any effects of the type of material.

Throughout the concrete battery the materials were colored shapes. Throughout the print battery the materials were words. The most important word concepts to be used were birds, rafts, and yellow treasures.

The foregoing twelve rules control for inference pattern. Three other guidelines Smedslund feels are important are:

(1) Does the task have continuity with previous research? These tasks were used by Rawson (1969) who adapted them from

Piaget (1964) and others who had tried to replicate Piaget's findings.

(ii) Does the task control variations in goal object (what the subject is instructed to attain)?

The test questions have specific correct answers.

(iii) Does the task control variations in perception?

The subject was presented with only those materials which were required for the test questions and the preliminary questions direct him to focus upon the percepts which he requires.

(b) Construct Validity of the Test Items - To examine if a test item has construct validity it is necessary to see if it can be represented in symbolic form. Then the degree of correspondence of its symbolic representation to the accepted logical representation for that operation is the measure of the validity of the test task.

The symbolic form of each item in both test batteries is given in Appendix C. The degree of correspondence to the accepted logical representation for that operation was examined by comparing the test item to the logical representation for the classification operations also presented in Appendix C. It seems that all of the test items were constructed in accordance with the necessary logical sequences.

VI. ADMINISTRATION OF THE EXPERIMENTAL TESTS

The experimental tests were administered during the period January 16 to February 7, 1973. Both batteries were administered individually in one sitting. Each subject was tested in a study room in his own school, and the average time per student was thirty-five minutes.

The student faced the investigator across a table. All of the materials were filed in a box out of the student's view, produced in sequence as needed, and then placed out of sight again after each set of questions was completed.

The sequence of presentation was concrete first, print second, for twenty-four subjects; print first, concrete second, for twenty-one subjects. All of the sessions were tape-recorded and the responses were transcribed later. These written transcriptions were used for scoring purposes.

The preliminary questions and the test questions were typed on 3" x 5" file cards. The students were told that the questions would be read to them so that everyone would be asked exactly the same questions at each administration. (See Appendix D for test batteries.)

VII. SCORING PROCEDURE

The scoring system which had been used by Rawson (1969) was modified.

Rawson had allowed a one or zero score for each item. On the class inclusion subtest the subject had to have a correct answer plus a correct explanation in order to obtain a score of one. On the predicates subtest the answer was in the form of a proposition which had to be correct in order to obtain a score of one. On the multiplicative subtest a score of one was given for the correct answer, and a score of one was given for the correct explanation.

The modification which was made to the scoring was to allow a score of one for the correct answer, and a score of one for the correct explanation, on the class inclusion as well as the multiplicative subtests. This modification was made in order that a comparison could be made between the answers-only and the answers-plus-explanation scores. The predicates subtest was scored in the same way as had been done by Rawson.

VIII. RELIABILITY OF SCORING

The reliability of the scoring was obtained by measuring inter-scorer agreement. A random sample of five subjects was scored by another marker, a Master of Education graduate in Reading. The marker was provided with a set of questions, a set of criteria for correctness, as is printed in Appendix D, and the taped protocols of the five students. For questions nine, ten and eleven of the predicate subtest, and question twelve of the multiplicative subtest, all from the concrete battery, a diagram of what the student had done was provided because the student had demonstrated his answer.

The Arrington Formula was used to compute the reliability score. The formula is (2 x agreements) ÷ ((2 x agreements) + disagreements). The percentage of agreement for the print battery was 95%, and for the concrete battery it was 98%. These percentages indicate that the reliability of the scoring may be considered quite satisfactory.

IX. THE PILOT STUDY

The purposes for administering a pilot study were to train the investigator in administering the tests, to determine the testing time needed for each student, to examine the possibility of using more than two stories, to decide whether the stories were too easy for Grades five and six students, and to examine the possibility for using scoring procedures different from those followed by Rawson.

The concrete and stories tests on classification were administered to eighteen students from Grades four, five and six from two different schools. The students were tested individually in a room at their school and all responses were tape-recorded.

Three students were chosen from each grade in each school by their classroom teacher, who used his/her judgement in picking a high, middle and low achiever in reading.

The time taken by the students, who had no time limitations imposed upon them, varied from 25 to 60 minutes with an average time of 40 minutes. Since this seemed to be a reasonable length of time, and created a comfortable testing climate, it was decided to allow the students as much time as they wanted during the main study as well.

Using more than Rawson's two stories produced the same results as using only two. The extra reading seemed burdensome to most of the children and it meant they spent a much longer proportion of their time reading than doing other test tasks. Also there seemed to be too many different concepts to remember, use, and forget within a very short interval of time. It was decided that only two stories would be administered in the main study.

The stories did not seem more or less easy for the Grade five and six students than for the Grade four students. Problems with the readability factor of the stories were minimized by the thoroughness of the preliminary questions presented before the test questions. A very precise set of preliminary questions and assistance guidelines was recognized by the investigator as being very important to ensure all students were given equal amounts of assistance prior to the test questions.

To use alternate scoring procedures was deemed a desirable adjustment that should be made. A better balance between the total possible score on the stories and concrete tests could be made by increasing the number of class inclusion questions on the stories battery. Also, more alternative answers to the intersection questions could be allowed, thus providing the children with the opportunity to reveal more information about their thinking.

X. STATISTICAL PROCEDURES

The statistical procedures for this study were programmed by the Division of Educational Research Services of the University of Alberta Faculty of Education.

Correlations

Product moment correlations were obtained between the scores on the concrete and print batteries; between reading comprehension scores and the scores on the concrete and print batteries; and between verbal IQ, non-verbal IQ, reading vocabulary, reading comprehension, and the concrete and print class inclusion totals for answers-only scores, and answers-plus-explanation scores. Correlations between two types of scoring were also obtained.

Mean Scores

The mean scores and standard deviations per grade were obtained for age, verbal IQ, non-verbal IQ, reading vocabulary, reading comprehension, concrete battery and print battery.

T-Tests

The significance of the difference between mean scores was obtained using t-tests to examine (1) the effect of the order of the test administration, and (2) the effect of sex.

Covariance

An analysis of covariance was computed to estimate the relationship of the print battery and the concrete battery scores to reading comprehension, reading vocabulary, verbal IQ, and non-verbal IQ scores.

Analysis of Variance

A two factor analysis of variance with repeated measures of factor B was computed in order to compare the change over grade levels of the print battery compared to the concrete battery.

z Test

The significance of the difference between two correlation coefficients for independent samples was computed using Fisher's z_r transformation. The correlations for each grade level between reading comprehension and classification, r_4, r_5, r_6, were converted to z_{r4}, z_{r5}, z_{r6}, using a transformation table.

The formula which follows gave the z scores (Ferguson, 1971).

$$z = \frac{z_{r1} - z_{r2}}{\sqrt{1/(N_1 - 3) + 1/(N_2 - 3)}}$$

It is a unit-normal-curve deviate. A value of 1.96 or greater is required for significance at the .05 level, and a value of 2.58 or greater is required for significance at the .01 level.[1]

XI. SUMMARY

This chapter has presented descriptions of the sample, the standardized and experimental tests, the scoring procedures, the validity and reliability of the tests and the scoring, the pilot study, and the statistical procedures employed to analyse the data.

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[1] Ferguson, G.A. Statistical Analysis in Psychology and Education. N.Y.: McGraw Hill Book Co., 3rd Edition, 1971, pp. 170-171, 456.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

I. INTRODUCTION

The purpose of this chapter is to present the results of the investigation. A description of the characteristics of the sample is presented. Results of a comparison between Rawson scoring and the scoring used in this study are interpreted. Following an analysis of the order-of-test-presentation effect, and the sex effect, the relationship between classification ability and reading comprehension over the three grade levels is examined. Also the relationship between classification ability in the print and concrete modes is examined. An analysis of the class inclusion subtest concludes the chapter.

II. DESCRIPTION OF THE SAMPLE

The sample for this study was composed of forty-five students, fifteen from each of the Grades four, five and six. Information on the means and standard deviations for age, reading vocabulary, reading comprehension, verbal IQ, and non-verbal IQ, is given in Table 1 for each grade group and the total sample. The number of boys and girls is also recorded. Scores were recorded from the cumulative records for the reading sections of the Canadian Tests of Basic Skills, and for the Lorge-Thorndike Intelligence Test. It may be seen by examining the standard deviations on Table 1 that there are very slight

TABLE 1

DESCRIPTION OF THE SAMPLE

GRADE GROUP	NO. OF PUPILS	NO. OF GIRLS	NO. OF BOYS		AGE (MOS.)	READING VOCABULARY	READING COMPREHENSION	VERBAL I.Q.	NON-VERBAL I.Q.
4	15	7	9	$\overline{X}$	114.86	40.80	42.47	105.60	104.20
				SD	4.113	7.120	7.518	14.705	13.541
5	15	8	7	$\overline{X}$	127,93	47.73	47.53	102.33	102.07
				SD	2.696	8.652	10.092	15.478	17.586
6	15	7	8	$\overline{X}$	142.00	63.80	66.53	100.00	109.20
				SD	5.989	8.666	9.845	11.349	12.249
TOTAL SAMPLE	45	22	23	$\overline{X}$	128.23	50.778	52.178	102.64	105.15
				SD		12.637	13.871	14.147	14.938

differences in age within the groups.

The performance of the subjects on the experimental tests is presented in Table 2. The mean scores and standard deviations for each grade group and the total sample are given for each subtest. The mean scores and standard deviations are also given for the total test score in both the concrete and print batteries. It should be noted that in both batteries the highest mean scores are attained by the Grade six group, and the lowest mean scores are attained by the Grade five group, except on the concrete predicate subtest. On the concrete predicate subtest the highest mean score is attained by the Grade five group and the lowest mean score is attained by the Grade four group.

The frequency distributions for the subtests and for the total batteries are illustrated in Figures 1, 2, 3, and 4.

III. COMPARISON OF THE SCORING METHOD DEVELOPED FOR THIS STUDY AND THE RAWSON METHOD OF SCORING

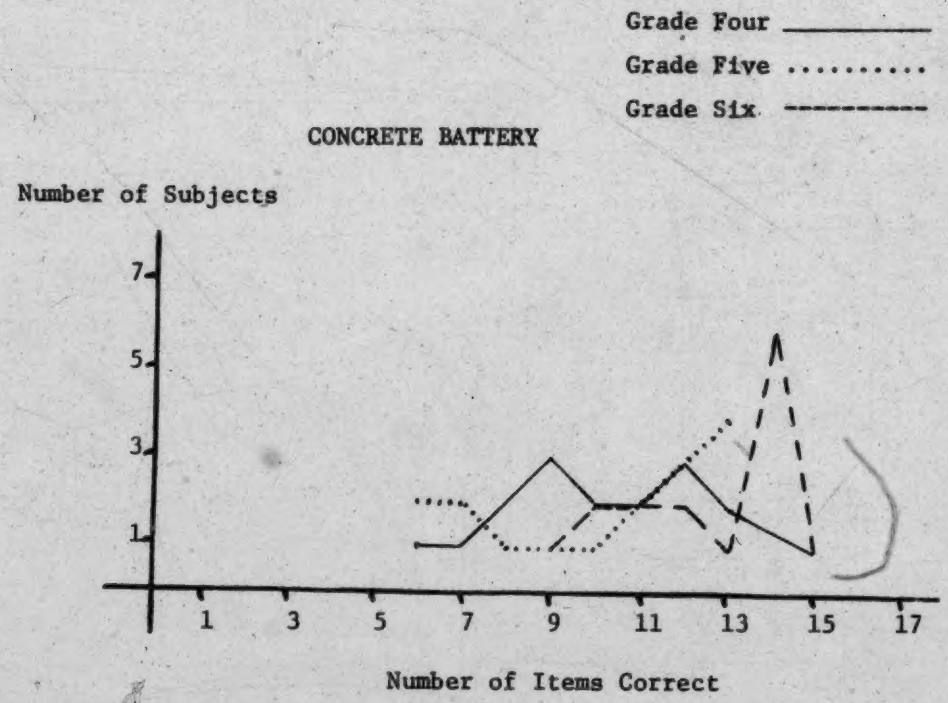
The experimental tests were scored using (1) Rawson's method of scoring, and (2) the method of scoring developed for this study. Rawson's method of scoring on the class inclusion subtests and the print intersection item was to allow a score of one on an item if the subject had both the answer and the explanation correct. On the concrete intersection subtest a score of one for the answer and an additional score of one for the explanation was allowed. In this study, a score of one was allowed for the answer, and a score of one was allowed for the explanation, on all subtests except predicates. On

TABLE 2

SUMMARY OF SCORES ON THE CLASSIFICATION TASKS

CONCRETE

TEST	NO. OF ITEMS	GRADE 4		GRADE 5		GRADE 6		TOTAL SAMPLE	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Class Inclusion	16	10.60	2.304	9.67	2.494	12.47	1.821	10.91	2.511
Predicate	3	1.67	1.247	2.00	0.966	1.87	0.806	1.84	1.032
Multiplicative	6	3.60	2.154	3.13	2.391	4.53	1.707	3.76	2.182
Total Score	25	15.87	3.947	14.80	3.781	18.87	1.893	16.51	3.757
PRINT									
Class Inclusion	16	7.33	2.891	7.20	3.270	7.87	2.418	7.47	2.895
Predicate	3	0.67	0.596	0.60	0.712	1.00	0.966	0.76	0.793
Multiplicative	6	2.07	1.692	1.73	1.652	2.87	1.147	2.22	1.590
Total Score	25	10.07	4.234	9.53	4.349	11.73	3.172	10.44	4.064



CONCRETE BATTERY

PRINT BATTERY

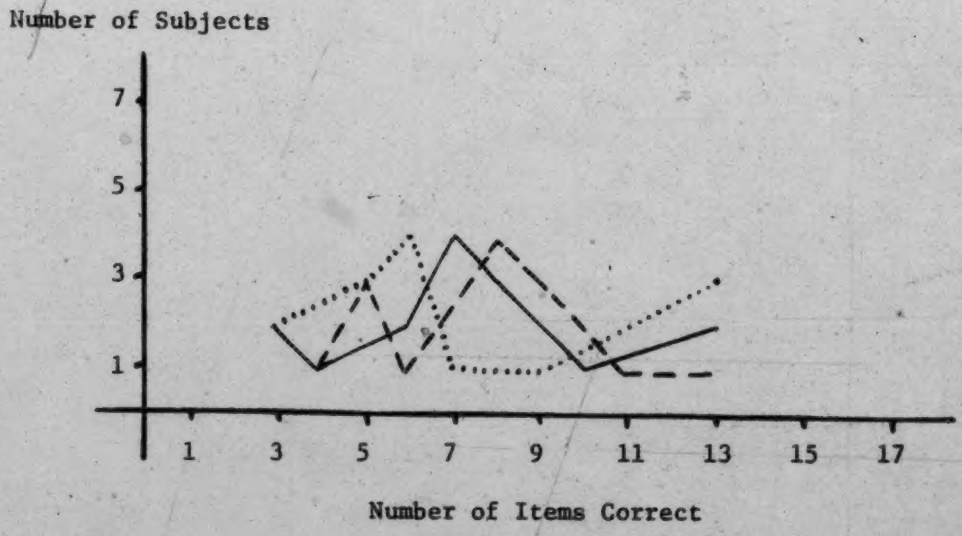


Figure 1. Frequency Distributions of Correct Scores on the Class Inclusion Subtest for the Three Grade Levels

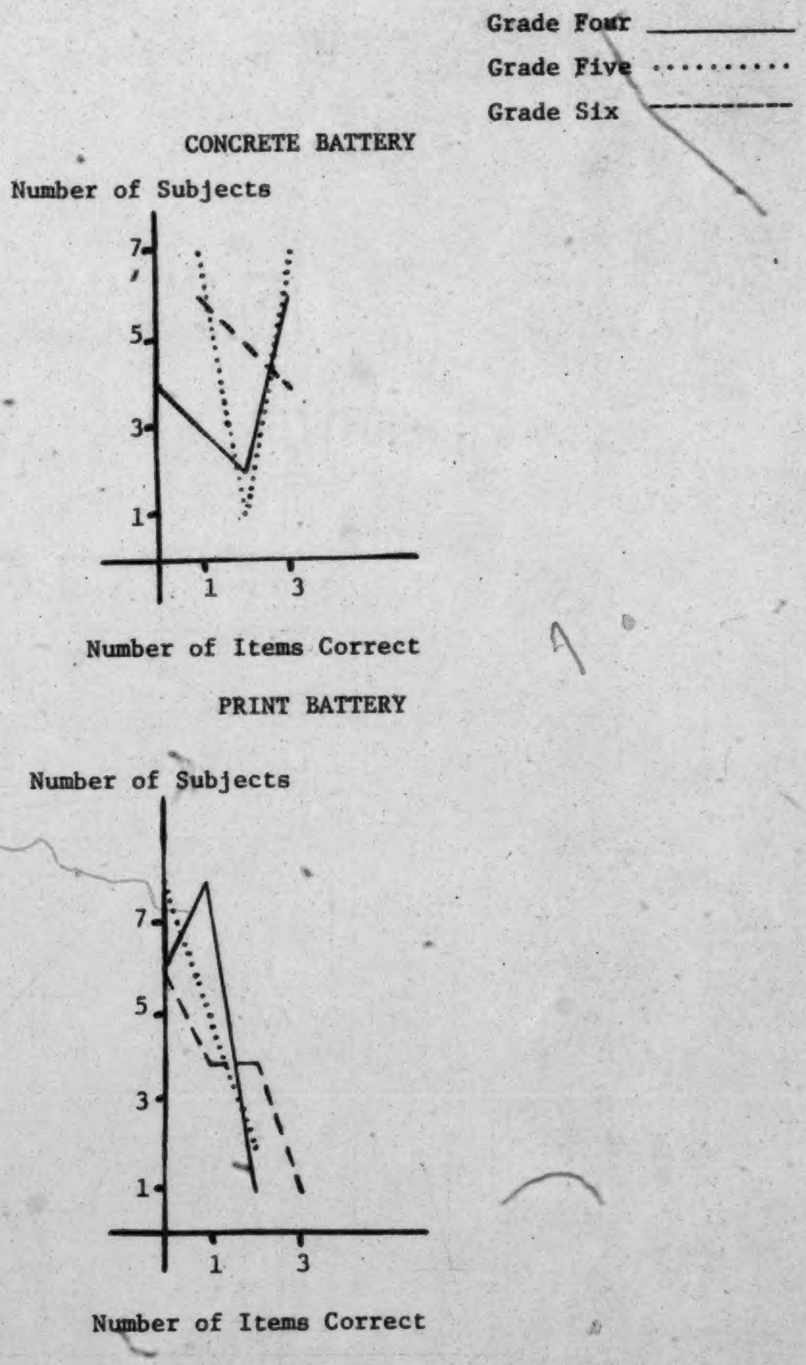


Figure 2. Frequency Distributions of Correct Scores on the Predicate Subtest for the Three Grade Levels

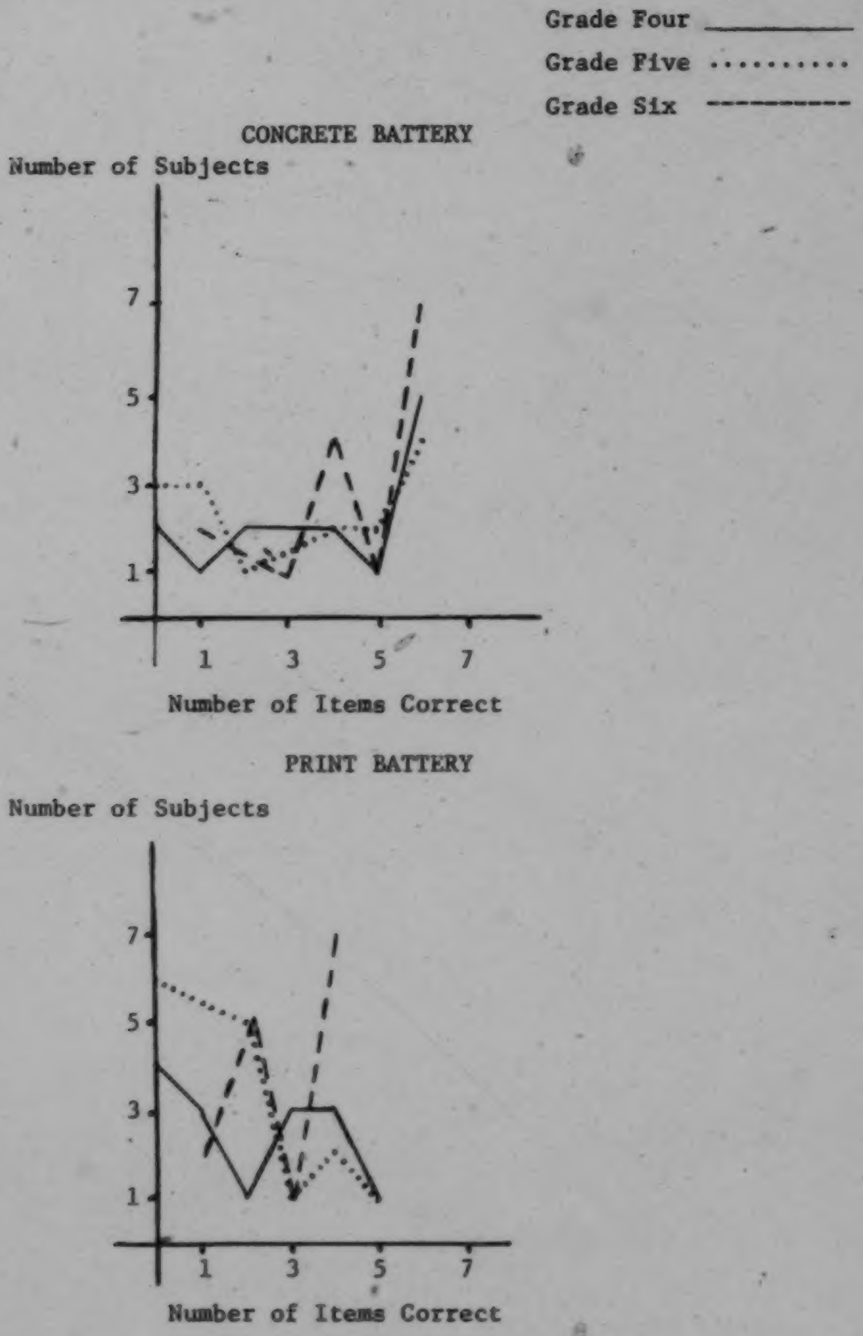


Figure 3. Frequency Distributions of Correct Scores on the Multiplicative Subtest for the Three Grade Levels

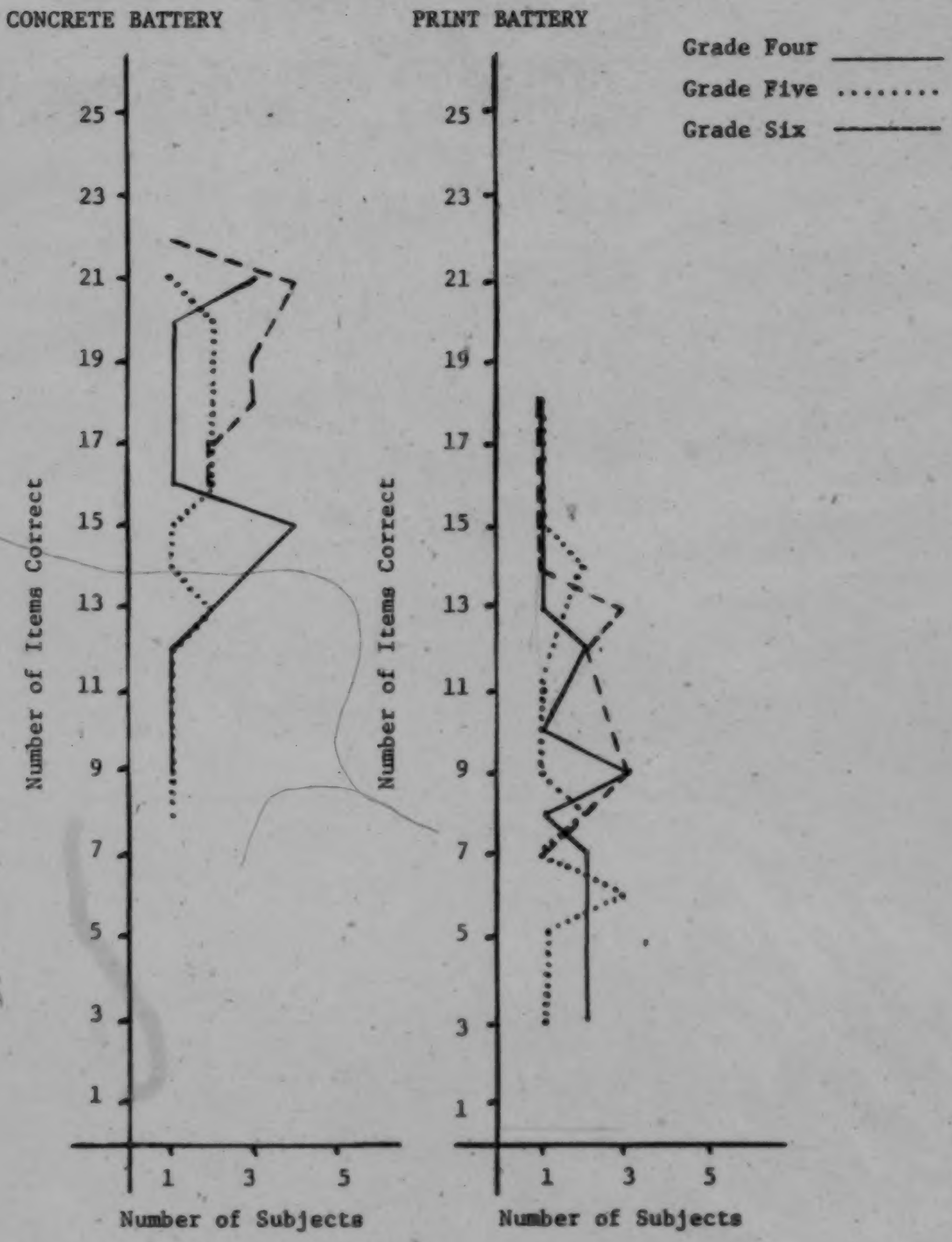


Figure 4. Frequency Distributions of Correct Scores on the Total Battery for the Three Grade Levels

the predicate subtest a score of one per item was allowed using both methods of scoring.

The scores obtained by the Rawson method are presented in Table 3. The scores are presented for all of the subtests and the total battery for each grade group and for the total sample. It is important to note the differences between the Rawson method of scoring and the scoring developed for this study, which is shown in Table 2, insofar as the total score possible on the subtests is concerned.

The effect of changing the quantity of test items so that there were equal numbers of concrete and print items can be observed in Table 4 by comparing Rawson's data for Grade four to the Grade four results for this study. The gap was lessened somewhat between the percent correct in concrete and print for the class inclusion subtest. There was little change made on the other subtests.

In order to determine if there were any significant differences between the two types of scoring, correlations between the scoring developed for this study and Rawson's method of scoring were made. The correlations between the two types of scoring are presented in Table 5. All scores, with the exception of both multiplicative subtests for Grade six, the print multiplicative subtest for Grade four, and the total concrete battery score for Grade six, are significantly correlated at the .01 level of significance. The perfect correlation on the predicate subtest is due to the fact that there was no change made in the scoring of this subtest for this study.

The very high correlation between the class inclusion subtests

TABLE 3

SUMMARY OF SCORES ON THE CLASSIFICATION TASKS USING RAWSON SCORING

CONCRETE

TEST	NO. OF ITEMS	GRADE 4		GRADE 5		GRADE 6		TOTAL SAMPLE	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Class Inclusion	8	4.40	1.497	4.07	1.526	5.67	1.075	4.71	1.544
Predicate	3	1.67	1.247	2.00	0.966	1.93	0.772	1.87	1.024
Multiplicative	6	1.20	0.833	1.87	1.746	1.87	1.258	1.64	1.369
Total Sample	19	9.20	2.344	9.93	2.816	11.33	1.350	10.16	2.422
			PRINT						
Class Inclusion	8	2.07	1.569	2.33	1.955	2.80	1.470	2.40	1.705
Predicate	3	0.67	0.596	0.60	0.712	1.00	0.966	0.76	0.793
Multiplicative	3	0.87	0.718	0.73	0.929	1.27	0.680	0.96	0.815
Total Sample	14	3.60	2.361	3.67	2.821	5.07	2.380	4.11	2.618

TABLE 4

SUMMARY OF PERCENT CORRECT ON CLASSIFICATION TESTS FROM RAWSON'S THESIS - Grade 4 only

SUBTEST	CONCRETE BATTERY		PRINT BATTERY	
	No. of Items	% Correct	No. of Items	% Correct
Class Inclusion	8	73	4	24
Predicate	3	60	3	30
Multiplicative	6	48	3	27
Total	19	64	10	27

FROM THIS STUDY - Grades 4, 5 and 6

SUBTEST	NO. OF ITEMS	GRADE 4		GRADE 5		GRADE 6		TOTAL	
		C	P	C	P	C	P	C	P
Class Inclusion	16	66.3	46.0	60.5	45.1	78.2	49.1	68.3	46.7
Predicate	3	55.5	22.1	66.5	19.9	62.2	33.3	61.4	25.1
Multiplicative	6	60.0	34.5	52.3	28.8	75.7	47.9	62.7	37.1
Total	25	63.5	40.3	59.2	38.1	75.5	46.9	66.1	41.5

TABLE 5

CORRELATIONS BETWEEN THE CLASSIFICATION SCORES OBTAINED USING THE SCORING METHOD DEVELOPED FOR THIS STUDY WITH THE RAWSON METHOD

CONCRETE BATTERY

GRADE	CLASS INCLUSION	PREDICATE	MULTIPLICATIVE	TOTAL
4	$.917^{**}$	1.000^{**}	$.714^{**}$	$.940^{**}$
5	$.934^{**}$	1.000^{**}	$.659^{**}$	$.888^{**}$
6	$.931^{**}$	1.000^{**}	.468	.409
TOTAL SAMPLE	$.939^{**}$	1.000^{**}	$.573^{**}$	$.841^{**}$
		PRINT BATTERY		
4	$.921^{**}$	1.000^{**}	.501	$.856^{**}$
5	$.907^{**}$	1.000^{**}	$.823^{**}$	$.906^{**}$
6	$.893^{**}$	1.000^{**}	.473	$.859^{**}$
TOTAL SAMPLE	$.903^{**}$	1.000^{**}	$.659^{**}$	$.877^{**}$

** .01 level of significance
* .05 level of significance

indicates that scoring the answers and explanations separately made little difference to the relative scores of the subjects at all grade levels. This high correlation was unexpected. It had been felt that scoring the answers and explanations separately would produce different results than scoring the answers and explanations together. Partly because of this finding, the class inclusion subtest will be analysed more closely in the final section of this chapter.

The poorest correlations were found on the multiplicative subtest. A probable reason for this is that more answers were accepted as correct by the scoring method used in this study than by the Rawson method, on both batteries. An examination of the scores for this subtest on both Table 2 and Table 3 reveals that the mean score is relatively higher by the scoring done in this study than by the Rawson method. However, these particular correlations are still positive and approach the .05 level of significance.

It seems that there is no significant difference between the two scoring methods. Therefore the method developed for this study will be used for analysing the data in this chapter.

IV. ORDER OF TEST PRESENTATION EFFECT

In order to observe whether transfer from one test battery to the other would occur, the sample was divided into two groups. The concrete test was administered first and the print test second to one group. The print test was administered first and the concrete test second to the other group. The mean scores for both groups on both batteries are presented in Table 6. Also shown are the results of the t-tests which were calculated in order to discover whether there would be a significant difference between the means of the two groups on either of the test batteries.

It may be seen that the probability score that was calculated without adjusting for differences between variances is almost the same as the adjusted probability.

It may be concluded from these P values that there was no transfer from either one of the test batteries to the other. Whether the print test or the concrete test was administered first did not have any effect upon the score the student attained in either of the two batteries.

V. SEX DIFFERENCES ON EXPERIMENTAL MEASURES

Although Rawson had found that sex had no effect upon the classification scores of the two batteries, in order to check if adding the Grade five and six populations to the Grade four population might produce different results, a comparison of the girls' scores and boys' scores was made. The mean scores of the groups is presented in Table 7. The results of the t-tests calculated for the scores are listed, and none of the subtests or total scores were significantly different between the two groups.

It may be concluded that there is no significant difference between boys and girls' performance in the two batteries.

TABLE 6

EFFECT OF THE ORDER OF PRESENTATION OF TESTS

(1 - concrete test first; 2 - print test first)

TEST BATTERY	$\overline{X}_1$	$\overline{X}_2$	SD_1	SD_2	T	P-Two Tail	Adjusted P-Two Tail
CONCRETE	16.75	16.24	3.78	3.78	.447	.65722	.65670
PRINT	10.46	10.43	4.03	4.30	.024	.98105	.98100

TABLE 7

DIFFERENCES BETWEEN BOYS AND GIRLS ON THE CLASSIFICATION TASKS

(1 - Males; 2 - Females)

CONCRETE

Subtest	$\overline{X}_1$	$\overline{X}_2$	SD_1	SD_2	T	P-TWO TAIL	ADJUSTED P-TWO TAIL
Class Inclusion	10.57	11.27	2.81	2.23	-.933	.35597	.35372
Predicate	2.09	1.59	1.04	1.01	1.623	.11180	.11155
Multiplicative	3.48	4.05	2.09	2.34	-.859	.39493	.39631
Total	16.13	16.91	4.14	3.46	-.683	.49821	.49659

PRINT

Subtest	$\overline{X}_1$	$\overline{X}_2$	SD_1	SD_2	T	P-TWO TAIL	ADJUSTED P-TWO TAIL
Class Inclusion	7.43	7.50	2.09	3.66	-.074	.94140	.94219
Predicate	0.87	0.64	0.92	0.66	.974	.33530	.33226
Multiplicative	2.04	2.41	1.58	1.65	-.759	.45212	.45260
Total	10.35	10.55	3.21	4.95	-.159	.87399	.87537

5

VI. OTHER FACTORS AFFECTING CLASSIFICATION SCORES

Analyses of covariance were computed in order to determine if any of the factors: reading vocabulary (RV), reading comprehension (RC), verbal intelligence (VIQ), or non-verbal intelligence (QIQ), contributed significantly to a higher classification score singly or in combination. Table 8 lists the probabilities of the homogeneity of regression of the factors listed above and the total print and total concrete scores.

None of the variables has a significant effect upon the total scores.

The effect of reading comprehension on the total concrete score approached significance at the .05 level. This may indicate that the child's performance on the concrete battery is significantly affected by his understanding of the verbal directions and questions, and his performance depends upon his verbal comprehension which is measured in part by the reading comprehension score.

Reading comprehension and reading vocabulary have nearly the same effect upon the total print score. This seems to indicate that there is a similar skill being measured in all three tasks.

Verbal and non-verbal I.Q. have about equal effect upon the concrete score. Verbal I.Q. has more effect than non-verbal I.Q. on the print score.

Reading ability seems to have more effect upon classification scores than either verbal or non-verbal intelligence, but it is not a statistically significant effect. It would appear, therefore, that

TABLE 8

RELATIONSHIP OF CLASSIFICATION SCORES TO READING AND INTELLIGENCE SCORES

VARIABLES	P-HOMOGENEITY OF REGRESSION
RV & TC	.342
RV & TP	.364
RC & TC	.085
RC & TP	.324
VIQ & TC	.736
VIQ & TP	.523
QIQ & TC	.772
QIQ & TP	.994
RC + RV & TC	.182
RC + RV & TP	.426

TP - Total Print Battery Score

TC - Total Concrete Battery Score

classification ability operates somewhat independently of reading ability and intelligence.

Summary

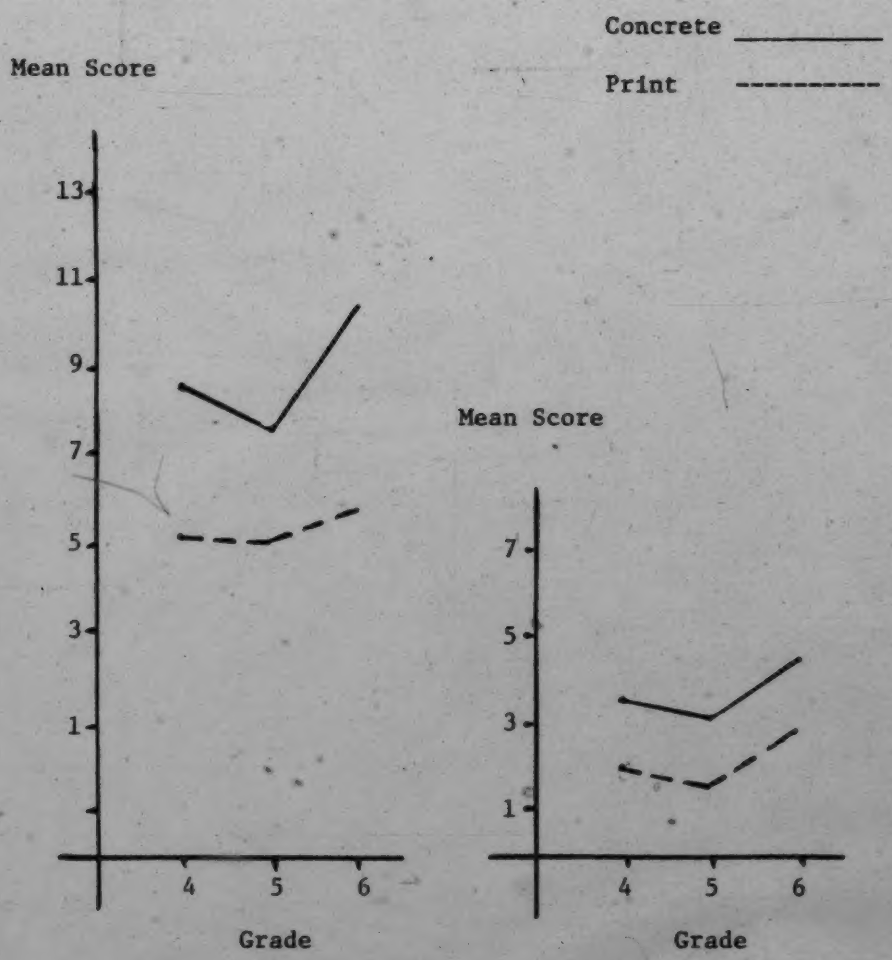
It was found that except on one subtest, the mean scores for the grade six group were consistently the highest, and that the grade four group was higher than the grade five group. There was no effect upon the mean test scores caused by order of test presentation or sex.

A comparison was made between the scoring method developed in this study and Rawson's method of scoring. Because the two methods seemed quite highly correlated, it was decided to use only the method developed for this study for the remainder of the data analyses of this chapter.

It seems that classification ability as measured by the tests in this study is not significantly affected by reading vocabulary, reading comprehension, verbal intelligence or non-verbal intelligence.

VII. RELATIONSHIP OF CLASSIFICATION ABILITY IN PRINT MODE AND CONCRETE MODE OVER THREE GRADE LEVELS

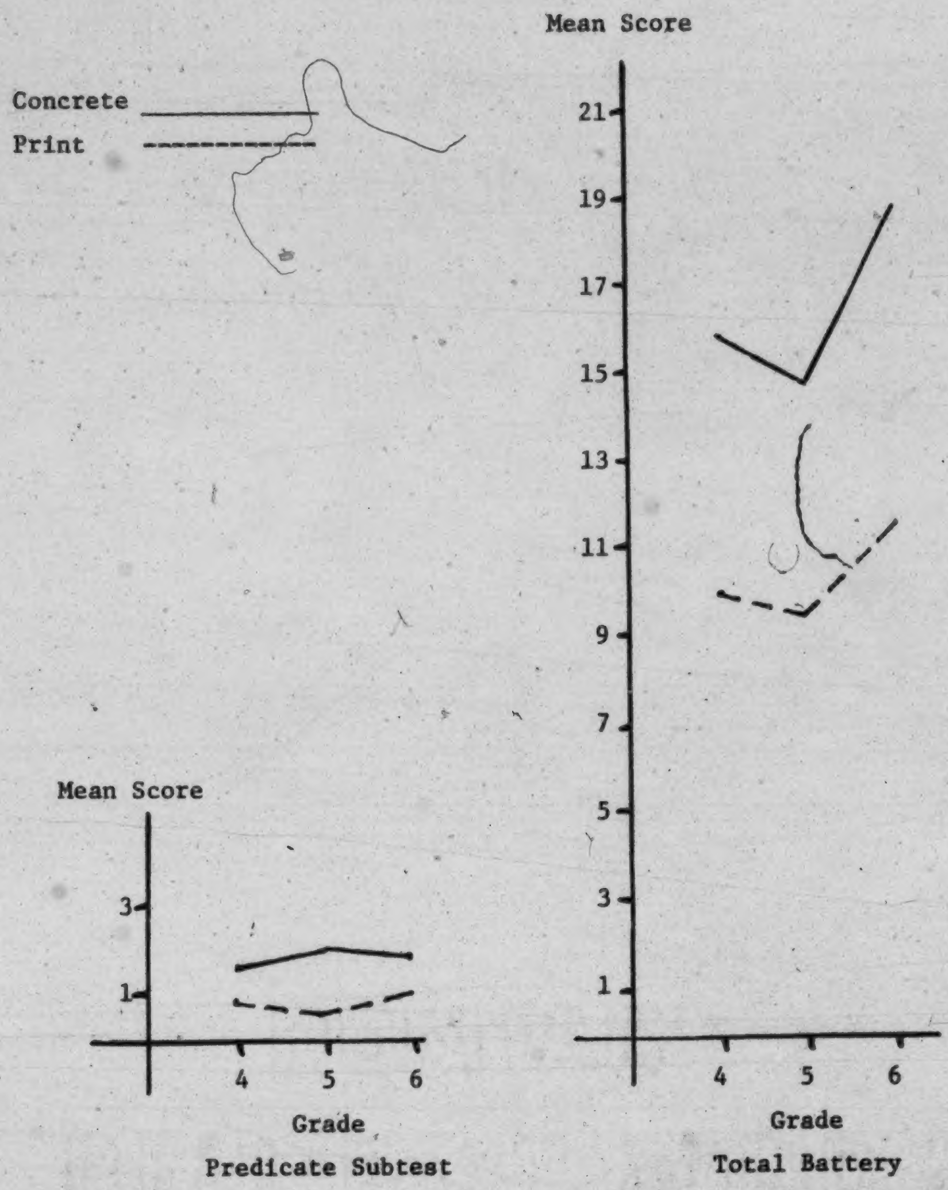
The relationship between the mean scores in the print and concrete batteries over the grade levels is illustrated in Figures 5 and 6. At every grade level the concrete score is higher than the print score. The relationship between the grades is that the Grade six group has the highest score and the Grade five group has the lowest score except on the print predicate subtest. On the print predicate



Class Inclusion Subtest

Multiplicative Subtest

Figure 5. Mean Scores on the Class Inclusion and Multiplicative Subtests



Predicate Subtest

Total Battery

Figure 6. Mean Scores on the Predicate Subtest and the Total Battery

subtest the Grade five group has the highest score and the Grade four group has the lowest score.

The change in classification scores over the grade levels is shown in Table 9. The difference between the modes, at each grade level, is significant at the .01 level. The difference between the modes from grade to grade is significant at the .05 level for the total scores only. There is no significant interaction of mode and grade. This means that at every grade level the concrete score is higher than the print score and at no grade level is the print score the higher one. The results also indicate that the difference between performance on the concrete battery in comparison to performance on the print battery is significantly greater at the Grade six level than at the Grade four and five levels.

Correlations between the two test batteries are recorded in Table 10. Significant correlations occurred on the multiplicative subtest in Grade six at the .05 level, and on the multiplicative subtest for the total group also at the .05 level. Correlations significant at the .01 level were obtained for the total group on the total score. No patterns seem to emerge; however, there are more positive than negative correlations.

VIII. RELATIONSHIP OF CLASSIFICATION ABILITY AND READING COMPREHENSION OVER THREE GRADE LEVELS

Correlations

Correlations of classification subtest and total battery scores

TABLE 9

CHANGE IN CLASSIFICATION TEST SCORES OVER THE GRADE LEVELS - TWO FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES ON FACTOR 'B'

VARIABLES	SOURCE OF VARIATION	SS	DF	MS	F	P
Grade (A) X CCI, PCI (B)	Between Subjects	408.289	44			
	'A' Main Effects	47.289	2	23.644	2.751	0.07539
	Subjects within groups	361.004	42	8.595		
	Within Subjects	519.500	45			
	'B' Main Effects	266.949	1	266.949	47.682	0.00000**
	'A' and 'B' Interaction	17.421	2	8.710	1.556	0.22292
	'B' X Subjects within Groups	235.133	42	5.598		
Grade (A) X CP, PP (B)	Between Subjects	35.400	44			
	'A' Main Effects	1.067	2	0.533	0.652	0.52599
	Subjects within Groups	34.333	42	0.817		
	Within Subjects	67.500	45			
	'B' Main Effects	26.678	1	26.678	28.247	0.00000**
	'A' and 'B' Interaction	1.156	2	0.578	0.612	0.54712
	'B' X Subjects within Groups	39.667	42	0.944		

Table 9 (continued)

VARIABLES	SOURCE OF VARIATION	SS	DF	MS	F	P
Grade (A) X CM, PM (B)	Between Subjects	214.489	44			
	'A' Main Effects	25.157	2	12.579	2.790	0.07281
	Subjects Within Groups	189.333	42	4.508		
	Within Subjects	166.500	45			
	'B' Main Effects	52.901	1	52.901	19.605	0.00006**
	'A' and 'B' Interaction	0.265	2	0.132	0.049	0.95220
	'B' X Subjects within Groups	113.333	42	2.698		
Grade (A) X TC, TP (B)	Between Subjects	954.957	44			
	'A' Main Effects	159.020	2	79.510	4.196	0.02181*
	Subjects Within Groups	795.938	42	18.951		
	Within Subjects	1251.500	45			
	'B' Main Effects	828.098	1	828.098	84.926	0.00000**
	'A' and 'B' Interaction	13.868	2	6.934	0.711	0.49689
	'B' X Subjects within Groups	409.535	42	9.751		

TABLE 10

CORRELATIONS BETWEEN CONCRETE AND PRINT TASKS

GRADE	CLASS INCLUSION	PREDICATE	MULTIPLICATIVE	TOTAL
4	.370	.209	-.048	.340
5	.466	-.388	.431	.485
6	-.470	-.086	.513*	-.128
Total	.238	-.074	.323*	.387**

** .01 level of significance

* .05 level of significance

with reading comprehension scores were obtained for each grade level and the total sample. The correlations are presented in Table 11.

A grade by grade analysis of the correlations reveals a different situation at the Grade five level than at the Grade four or six levels on the concrete battery. Correlations between reading comprehension and concrete classification are near zero or negative in Grade four and six, but correlated significantly at the .01 level in grade five. The significant correlations in Grade five are for the class inclusion subtest and for the total battery.

These differing results on the class inclusion subtest seem to indicate that there is a difference between the thinking of the Grade five students and the Grade four and six students in this operation. Perhaps the nature of the class inclusion subtest caused the Grade five group to perform on it similarly to their reading comprehension test performance, while the other two groups did not, or perhaps the method of presenting the class inclusion subtest affected their performance differently. Inhelder and Piaget (1964) found that children between seven and eleven years old begin to rely less and less on perceptual modes of solution, but are still not competent with operational thought. The result is that older children sometimes score less well than younger children on a task that involves operational thought about concrete objects. The concrete class inclusion subtest is such a task, and perhaps each grade group saw and used the lay-outs to be perceived differently.

Research findings of Wohlwill (1968) and I. E. Sigel (1971)

TABLE 11

CORRELATIONS BETWEEN READING COMPREHENSION AND CLASSIFICATION TEST SCORES

BATTERY AND SUBTEST	GRADE 4	GRADE 5	GRADE 6	TOTAL SAMPLE
CCl	-.066	.717**	-.133	.437**
CP	.109	.007	-.403	.018
CM	-.058	.276	.380	.305
TC	-.036	.649**	.043	.464**
PCI	.398	.581*	.067	.313*
PP	.198	.568*	.519*	.454**
PM	.060	.608**	.603**	.465**
TP	.324	.761**	.427	.493**

** .01 level of significance

* .05 level of significance

may be related to the performance of the three grade groups on the concrete battery. They found that for some children the presence of objects assists thinking, but for others the presence of objects interferes with thinking. Wohlwill (1968) found in two of three experiments, children of Grades five and seven did better on oral-verbal class inclusion questions than on picture-related ones, concluding that the visual lay-out interfered with their reasoning. I. E. Sigel (1971, p. 178) reported that in training classification skills with young children it was found that they had difficulty when introduced to pictures and objects simultaneously. This caused a regression in performance. He suggests that perhaps there was an interference induced by this procedure whereby the children became confused and hence could not establish an equivalence relation between object and picture. They could label both, but did not realize they were members of the same information class. The reason why the Grade five group performed differently to the Grade four and six groups may be that each of the groups were influenced differently by the visual layouts that were presented at the outset of each subtest.

A grade by grade analysis of the print battery reveals that except for the class inclusion battery, there are significant correlations at the Grade five and six levels but none at the Grade four level. The trend over the grade levels seems to be a change from no significance in Grade four to significance at the .01 and .05 levels in Grade five and Grade six.

Correlations for the total sample as shown in Table 11 indicate that there seems to be a relationship between classification ability and reading comprehension. On the print battery three of the correlations are significant at the .01 level, and one, class inclusion relations, at the .05 level. On the concrete battery the class inclusion subtest and the total score for the battery are significantly correlated with reading comprehension at the .01 level of significance. It seems that for the total sample, the classification of print tasks is more closely related to reading comprehension than the classification of concrete tasks. A possible reason for the very significant relationship of the class inclusion subtest on the concrete battery may be that the presentation and response are more verbal on this subtest than on the other subtests. (See Appendix B.)

Because of the unusual correlations between reading comprehension and the class inclusion subtest, especially in the concrete battery, a more in-depth analysis of the class inclusion subtest was undertaken and will be presented in the last section of this chapter.

Significance of the Difference Between the Correlations of Classification and Reading Comprehension Among the Grade Levels

To examine the difference among the grade levels between the correlations of classification and reading comprehension, a z-test was performed. Table 12 shows the results of the test for the concrete battery. Table 13 shows the results of the test for the print battery.

Only on the concrete class inclusion subtest is there a significant change between the correlations between the grades. Both

TABLE 12

SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE GRADES OF THE CORRELATIONS BETWEEN CONCRETE CLASSIFICATION AND READING COMPREHENSION

VARIABLE	z_{r4}	z_{r5}	z_{r6}	GROUPS COMPARED	z
CCI	-.066	.901	-.134	4 & 5	2.37*
				5 & 6	2.54*
				4 & 6	.17
CP	.109	.007	-.427	4 & 5	.25
				5 & 6	1.06
				4 & 6	1.31
CM	-.058	.283	.400	4 & 5	.84
				5 & 6	.29
				4 & 6	1.12
TC	-.036	.773	.043	4 & 5	1.98*
				5 & 6	1.79
				4 & 6	.19

**p = .01 if $z \geq 2.58$

*p = .05 if $z \geq 1.98$

r4 - correlation of Grade 4

r5 - correlation of Grade 5

r6 - correlation of Grade 6

TABLE 13

SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE GRADES OF THE CORRELATIONS BETWEEN PRINT CLASSIFICATION AND READING COMPREHENSION

VARIABLE	z_{r4}	z_{r5}	z_{r6}	GROUPS COMPARED	z
PCI	.421	.662	.067	4 & 5	.59
				5 & 6	1.46
				4 & 6	.87
PP	.201	.644	.575	4 & 5	1.09
				5 & 6	.17
				4 & 6	.92
PM	.060	.705	.697	4 & 5	1.58
				5 & 6	.00
				4 & 6	1.56
TP	.336	.998	.456	4 & 5	1.62
				5 & 6	1.33
				4 & 6	.29

$^{**}p = .01$ if $z \geq 2.58$

$^{*}p = .05$ if $z \geq 1.98$

r4 - correlation of Grade 4

r5 - correlation of Grade 5

r6 - correlation of Grade 6

the Grade four and Grade six groups differ from the Grade five group, but not from each other.

It seems that the correlation between classification and reading comprehension scores do not change significantly over the grade levels.

It was found that the class inclusion subtest results on the concrete battery differed from those of the other subtests, a further indication that a closer look at this subtest is justified.

Summary

The relationship between reading comprehension scores and classification scores is more significant at all grade levels for the print classification battery than for the concrete classification battery. There was in general no significant difference among the grade levels between the correlations. However, for the Grade five group there was a significant correlation at the .05 level between reading comprehension and the concrete class inclusion score, and this correlation differed significantly from that of Grade four and of Grade six.

Because the correlations for the class inclusion subtest on both batteries differed from the other subtests, a further analysis of that particular subtest will be carried out in the last section of this chapter.

IX. ANALYSIS OF THE CLASS INCLUSION SUBTEST

Since the class inclusion subtest seemed to produce different results from the other subtests, a closer examination was undertaken. The particular results in question are:

(i) that an expected difference between the answer-plus-explanation scores, and the answers-only scores was not observed,

(ii) that there is a significant correlation between concrete class inclusion and reading comprehension at only the Grade 5 level,

(iii) that the difference in the correlations between classification and reading comprehension among the grades is not significant except for the concrete class inclusion subtest,

(iv) that there is a trend towards significance over the grade levels in the relationship between print classification and reading comprehension except on the class inclusion subtest,

(v) that there is a significant correlation for the total sample between the concrete class inclusion subtest and reading comprehension at the .01 level of significance, but no correlations with the other subtests in the concrete battery and reading comprehension; and, that there is a significant correlation for the total sample between the print class inclusion subtest and reading comprehension at the .05 level of significance, but there are correlations at the .01 level between the other subtests in the print battery and reading comprehension.

An examination of Table 14 reveals that there is a variation between the items on the class inclusion subtest answer and explanation totals but the answer and explanation totals per item on the multiplicative subtest are similar. Because of this situation an

TABLE 14

SCORES ON THE CLASSIFICATION SUBTESTS CLASS INCLUSION AND MULTIPLICATION SHOWING ANSWER (A) AND EXPLANATION (E) TOTALS SEPARATELY

CONCRETE BATTERY

SUBTEST	ITEM NO.	GRADE 4		GRADE 5		GRADE 6		TOTAL GROUP	
		A	E	A	E	A	E	A	E
Class Inclusion	1	9	1	6	2	8	4	23	7
	2	15	13	15	15	15	15	45	43
	3	10	9	7	6	13	13	30	28
	4	15	6	13	2	14	3	42	11
	5	15	13	14	14	14	13	43	40
	6	9	8	12	8	12	12	33	28
	7	10	8	8	8	14	14	32	30
	8	9	9	8	7	11	12	28	28
Multiplicative	12	8	10	8	9	13	11	29	30
	14	11	11	8	8	13	13	32	32
	15	7	7	7	7	9	9	23	23

TABLE 14 (continued)

PRINT BATTERY

SUBTEST	ITEM NO.	GRADE 4 A	GRADE 4 E	GRADE 5 A	GRADE 5 E	GRADE 6 A	GRADE 6 E	TOTAL GROUP A	TOTAL GROUP E
Class Inclusion	1	3	1	6	0	4	0	13	1
	2	8	1	7	0	8	4	23	5
	3	15	12	14	11	12	12	41	35
	4	13	4	13	5	11	4	37	13
	5	11	4	9	6	13	10	32	20
	6	10	4	10	7	10	3	30	14
	7	10	2	8	3	10	4	28	9
	8	7	5	6	3	9	5	22	13
Multiplicative	12	2	5	1	3	3	6	6	14
	14	8	8	9	9	13	13	30	30
	15	4	4	2	2	4	4	10	10

examination of the answers and explanations scores was made separately, and a comparison of the answers-only totals with the answers-plus-explanations totals was made. This was done in order to determine if the explanations in the class inclusion subtest contributed to the different results that were observed. The answers-only score is consistently higher than the explanations-only score indicating that the explanation seems to be more difficult than the answer.

Since the Grade 5 group performed differently to the other two groups on this subtest, an examination of their performance was made, and compared to the performance of the other two grades.

The average reading comprehension score of the Grade five students is less than half-way between the average scores of the Grade four and Grade six groups. (See Table 1.) The Grade five group also scored lower on the class inclusion subtest than the other two grade groups. Over the total sample the student's reading comprehension did not have a significant effect upon the classification score. However, there was a positive effect indicated by the homogeneity-of-regression probability shown in Table 8, and a significant relationship indicated by the correlations shown in Table 11. It seems that perhaps the reason that the Grade five students scored lower in reading comprehension may also be the reason they scored lower in concrete classification. This finding concurs with studies reviewed in Chapter II by Wickens (1963), J. S. Braun (1963), Jan-Tausch (1962), and Rawson (1969). According to these authors the reason may be that these students have poorer abstracting ability.

The significant difference between the grades being only on the concrete class inclusion subtest at the Grade five level is best illustrated in Figures 5 and 6 which show that the drop is greater on the class inclusion subtest than on any of the others. The explanation for it may be the factor hypothesized in the preceding paragraph, that the Grade five students have poorer abstracting ability than the Grade four and Grade six students.

A trend towards significance was observed in the print battery from Grade four through Grade five to Grade six, between reading comprehension and print classification. There is a difference in the trend on the class inclusion subtest however. This seems to be due to a difference in performance by the Grade six group on the class inclusion subtest than on the other two subtests. Figures 5 and 6 illustrate that they do much better on the class inclusion subtest in relation to the Grade four students than on the other two subtests. By calculating the average scores for answers-only, explanations-only, at the Grade four and Grade six levels, it can be seen that whereas the average number of correct answers is about the same, 9.6 and 9.5, respectively, the average number of correct explanations differs. It is 4.1 for Grade four and 5.3 for Grade six. It seems that the better competency of the Grade six group over the Grade four group in explaining may account for the difference in the trend. The reason for their better competency may be that for this particular type of classification operation they are reaching a stage of equilibration as defined by Piaget (1964). This would mean that the Grade six students would be ready for beginning the formal operations stage in this operation, class inclusion relations, and they would nearly all have mastered class inclusion concepts based on concrete stimuli. Therefore more of them would be able to explain the operations than Grade four students.

The reason for the difference in the significance of the correlation for the class inclusion subtest for the total group from .01 significance in the concrete to .05 significance in the print may be explained by the effect of the Grade five and Grade six scores on the total group score. (See Table 11.)

It seems that explaining class inclusion operations in terms of concrete stimuli is less difficult than in terms of print stimuli. There are more items for which the answers-total and explanations-total are similar in the concrete battery than in the print battery. (See Table 14.)

In order to determine if particular class inclusion operations were more difficult than others, the average scores by operations were obtained. The results are shown in Table 15. There is a wider gap between the answers-total and the explanations-total in the print battery than in the concrete battery. Complete class inclusion scores are lower than partial class inclusion scores in both batteries. However, the gap between the answers-total and the explanations-total is wider on the partial class inclusion items than on the complete class inclusion items.

Explanations of print stimuli are much more difficult for these students than explanations of concrete stimuli on class

TABLE 15

AVERAGE SCORES OBTAINED ON CLASS INCLUSION ITEMS GROUPED ACCORDING TO OPERATIONS BEING TESTED

OPERATION TESTED	BATTERY AND ITEMS	AVERAGE SCORE A	E
complete class inclusion, type 1, and empty class	concrete 3, 7, 8	30	28.7
complete class inclusion, type 2, and complement	print 1, 2, 5, 7	24	8.75
partial class inclusion, type 2	concrete 1, 2, 4, 5, 6	37.2	25.8
partial class inclusion, type 2	print 3, 4, 6, 8	32.5	8.75

inclusion questions. The complete class inclusion operations seem to be more difficult than the partial class inclusion operations to answer, although the students seem to have more difficulty explaining a partial class inclusion question than a complete class inclusion question.

A summary of the mean scores of answers-only is given in Table 16. The performance at each grade level is compared with the scores of answers-plus-explanations scores in Figure 7. The symbols used are CCI for Concrete class inclusion answers-plus-explanations, PCI for Print class inclusion answers-plus-explanations, CIN for Concrete class inclusion answers-only, and PIN for Print class inclusion answers-only. The CIN score is always larger than the PIN score and the CCI score is always larger than the PCI score.

The relationship between the grades for the concrete battery using both types of scores is that the Grade six group is highest and the Grade four group lowest. The larger gap between Grade six and Grade four for the answers-plus-explanations score (CCI) than for the answers-only score (CIN) can be observed.

The relationship in the print battery is that the Grade six score is highest and the Grade five score is lowest using answers-plus-explanations (PCI) scores, but the Grade four score is highest and the Grade five score is lowest using answers-only (PIN) scores. The better performance of the Grade six group than the Grade four group when explanations are considered may be due to the higher level of Piagetian competency of the Grade six group as was discussed earlier.

TABLE 16

ANSWERS-ONLY SCORES ON THE CLASS INCLUSION SUBTEST

CONCRETE BATTERY

NO. OF ITEMS		GRADE 4	GRADE 5	GRADE 6	TOTAL
8	$\overline{X}$	6.13	5.53	6.73	6.13
	SD	1.0873	1.2037	0.9977	1.2037

PRINT BATTERY

NO. OF ITEMS		GRADE 4	GRADE 5	GRADE 6	TOTAL
8	$\overline{X}$	5.13	4.87	5.07	5.02
	SD	1.7075	1.7075	1.2893	1.5845

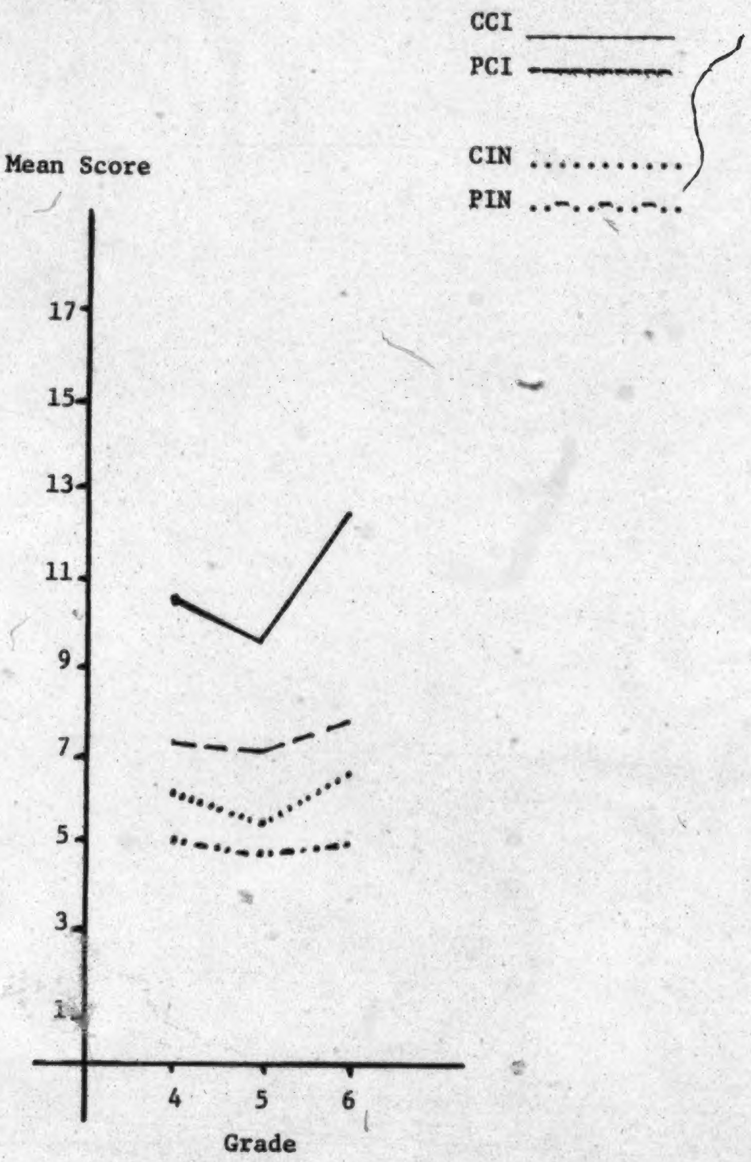


Figure 7. A Comparison of the Class Inclusion Scores at Each Grade Level Using Answers-Only (CIN and PIN) and Answers-Plus-Explanation (CCI and PCI) Scores

To discover whether any significant differences between the answers-only scores and the answers-plus-explanations scores existed, a comparison was made of the correlations between CCI, PCI, CIN, and PIN, with the factors of intelligence and reading. This information is to be found in Table 17. There is very little difference in the correlations between CCI and reading and intelligence, and CIN, and reading and intelligence. There is a somewhat higher correlation between PCI and reading and intelligence, than between PIN and reading and intelligence.

The correlation between PCI and CCI is higher than between CIN and PIN at every grade level. This seems to indicate that the answer-plus-explanation score is a somewhat better predictor of classification ability in one mode for another mode than the answer-only score.

Summary

A special analysis of the class inclusion subtest was carried out because of the difference in results of the subtest compared to the other subtests. It was found that the Grade five group performed differently on the concrete class inclusion subtest than the other grade groups. It was postulated that this might be related to their relatively lower reading comprehension ability and that both scores may be due to their relatively poorer abstracting ability. It was found that the Grade six group performed differently on the print class inclusion subtest than on the other subtests in relation to the other grade groups. It was assumed that this could be because of

TABLE 17

CORRELATIONS BETWEEN VIQ, QIQ, RV, RC, AND CCI, PCI, AND CIN, PIN

		1 VIQ	2 QIQ	3 RV	4 RC	5 CCI	6 PCI	7 CIN	8 PIN
1 VIQ	4	1							
	5	1							
	6	1							
	T	1							
2 QIQ	4	.521*	1						
	5	.655**	1						
	6	.639**	1						
	T	.565**	1						
3 RV	4	.728**	.511*	1					
	5	.613*	.488	1					
	6	.780**	.571*	1					
	T	.321*	.452**	1					
4 RC	4	.760**	.325	.673**	1				
	5	.618**	.551*	.845**	1				
	6	.628**	.665**	.588*	1				
	T	.315*	.471**	.871**	1				
5 CCI	4	.009	.261	.267	-.066	1			
	5	.500	.578*	.635**	.717**	1			
	6	.113	.011	-.095	-.133	1			
	T	.162	.393**	.460**	.437**	1			
6 PCI	4	.391*	.363	.233	.398	.370	1		
	5	.473	.310	.603*	.581*	.466	1		
	6	.095	.019	.285	.067	-.470	1		
	T	.340*	.271	.321*	.313	.238	1		
7 CIN	4	.312	.288	.365	.074			1	
	5	.363	.439	.596*	.619**			1	
	6	.071	-.056	-.153	-.108			1	
	T	.218	.318*	.380**	.369**			1	
8 PIN	4	.233	.296	.057	.302			.062	1
	5	.262	.131	.332	.236			.132	1
	6	.255	-.043	.234	.108			-.504	1
	T	.249	.150	.136	.145			-.025	1

**.01 level of significance

*.05 level of significance

their better ability to explain their answers, if they got the correct answers, than the Grade four and Grade five students. This competence was postulated as perhaps being related to their level of development as defined by Piaget (1964).

A further examination of the answers-only scores and the answers-plus-explanations scores resulted in the discoveries that: (i) it is easier to answer than to explain a class inclusion question, (ii) it is easier to explain answers about concrete than print stimuli, (iii) complete class inclusion operations seem to be more difficult than partial class inclusion operations, although the latter seem to be more difficult to explain, and (iv) the explanation seems to add information about classification ability to the answers, insofar as comparing performance in two modes is concerned.

X. SUMMARY

This chapter has presented the results of the investigation.

A description of the sample, which included information about the age, sex, intelligence, reading scores and experimental test scores of each student was provided. The scoring method developed for this study was compared to the Rawson method. Because there was no significant difference between the two methods, only the scores from the method developed for this study were used for analysing the data collected.

It was determined that there was no transfer from one test battery to the other during an individual testing session. No significant difference between boys' and girls' performance in the two batteries was observed.

Classification ability as measured by the tests in this study was not significantly affected by reading vocabulary, reading comprehension, verbal intelligence, or non-verbal intelligence.

A comparison of the relationship between the performance of the grade groups in the two modes was made. The relationship between reading comprehension and classification in the print and concrete mode was investigated.

An analysis of the class inclusion subtest concluded the chapter.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

I. SUMMARY

The main purpose of this study was to examine the relationship between classification scores, in a concrete mode and in a print mode, and reading comprehension scores over three grade levels: four, five and six.

The sample for the study consisted of forty-five students, fifteen from each of the three grades four, five, and six. These were chosen from the total population of Grade four, five and six students in one school in the Edmonton Public School system by means of a table of random numbers.

The classification tests, which were made up of a concrete battery and a print battery, were administered individually to each student. All responses were tape recorded, transcribed, and analyzed according to the criteria of correctness established for each item.

II. FINDINGS AND CONCLUSIONS

Hypothesis I

There is no significant difference between the scores attained by boys and girls on the concrete or print classificatory batteries.

The hypothesis was accepted.

The mean scores of the group of Grade four, five and six girls were compared to the mean scores of the group of Grade four, five and six boys. T-test calculations proved that there were no significant differences between the groups on any of the subtest and total battery scores.

It may be concluded that boys and girls perform in a like manner on concrete classification tasks and print classification tasks.

Hypothesis 2

There is no significant change over the three grade levels in the correlation between the scores attained on the concrete classificatory battery and reading vocabulary, reading comprehension, verbal intelligence and non-verbal intelligence.

The hypothesis was accepted.

The mean scores for the total group of Grade four, five, and six students in reading vocabulary, reading comprehension, verbal intelligence and non-verbal intelligence were compared to the mean score for the total group in concrete classification. It was found that none of these scores were significantly related to the classification score.

It may be concluded that there is no change in the concrete classification score over the grade levels that is attributable to the child's reading vocabulary, reading comprehension, verbal intelligence or non-verbal intelligence scores.

Hypothesis 3

There is no significant change over the three grade levels in the correlation between the scores attained on the print classificatory battery and reading vocabulary, reading comprehension, verbal intelligence, and non-verbal intelligence.

The hypothesis was accepted.

The mean scores for the total group of Grade four, five, and six students in reading vocabulary, reading comprehension, verbal intelligence and non-verbal intelligence were compared to the mean score for the total group in print classification. It was found that none of these scores were significantly related to the classification score.

It may be concluded that there is no change in the print classification score over the grade levels that is attributable to the child's reading vocabulary, reading comprehension, verbal intelligence or non-verbal intelligence scores.

Hypothesis 4

There is no significant interaction between mode and grade for the print and concrete classificatory test batteries over the three grade levels.

The hypothesis was accepted.

The classification subtest and total battery scores for each grade level were compared using a two factor analysis of variance. There was no significant interaction of mode and grade for any of the subtests and any of the grade levels. The concrete score was always higher than the print score.

It may be concluded that for Grade four, five and six students, classification tasks in a concrete mode seem to be easier to understand than classification tasks in a print mode.

Hypothesis 5

There is no significant difference between the modes at each grade level.

The hypothesis was rejected.

The difference between the modes at each grade level was significant at the .01 level. The concrete score was higher than the print score at every grade.

It may be concluded that for Grade four, five and six students classification tasks in a concrete mode are significantly easier to understand than classification tasks in a print mode.

Hypothesis 6

There is no significant change in the difference between the modes over the three grade levels.

The hypothesis was accepted for the subtest scores.

The difference between the print classificatory battery score and the concrete classificatory battery score between the grades was not significant for the subtests. The probability for each subtest was: class inclusion, .08, predicate, .53, and multiplicative, .07.

The hypothesis was rejected for the total battery scores.

For the total battery scores the difference between the modes from grade to grade was significant at the .05 level. The graph in Figure 8 illustrates that the gap between the concrete and print score is wider for the Grade six group than for the Grade four and Grade five groups.

It may be concluded that the difference between the score in the concrete battery and the score in the print battery for each of the subtests does not change from Grade four through six; however, there is a significant difference between the total scores in each battery from Grades four through six. It seems that overall the Grade six group does significantly better on the concrete battery than the Grade four and Grade five groups.

Hypothesis 7

There is no significant correlation between classification scores in the print mode and in the concrete mode at each grade level.

The hypothesis was rejected for one grade level, and accepted for two grade levels.

Significant correlations were found for the Grade six group on the multiplicative subtest. This was at the .05 level of significance. No significant correlations were observed for the Grade four and Grade five groups.

The total scores for the total group were significantly correlated at the .01 level which is an indication that there may be a trend towards significance in the relationship.

It may be concluded that because there was not a significant correlation between classification scores in the print mode and the concrete mode at the Grade four and Grade five levels, while there was a significant correlation at the Grade six level and for the total group, there may be a trend towards a significant correlation between the print and concrete mode.

Hypothesis 8

There is no significant difference in the correlation between print classification scores and concrete classification scores over the grade levels.

A difference in the correlations between print and concrete classification scores from grade to grade can be observed in Table 10. On the class inclusion subtest and on the total battery score there are negative correlations for the Grade six group but positive correlations for the Grade four and Grade five groups. On the multiplicative subtest the correlation is negative for Grade four, positive for Grade five, and significantly positive at the .05 level for Grade six.

It may be concluded that there are some differences between the correlations between the two batteries over the grade levels.

Hypothesis 9

There is no significant correlation between reading comprehension scores and classification scores in the concrete mode and in the print mode at each grade level.

The hypothesis was rejected in part.

Correlations between reading comprehension and concrete classification were near zero or negative for the Grade four and Grade six groups. For the Grade five group there was a correlation significant at the .01 level for the class inclusion subtest and for the total battery.

Correlations between reading comprehension and print classification were significant at the .05 level for the Grade five group on the class inclusion and predicate subtests, and at the .01 level for the Grade five group on the multiplicative subtest and the total score. The correlations for the Grade six group were significant at the .05 level for the predicate subtest, at the .01 level for the multiplicative subtest and not significant for the class inclusion subtest nor the total battery score. There were no significant correlations for the Grade four group.

It may be concluded that the classification of print stimuli seemed to be more closely related to reading comprehension than the classification of concrete stimuli. There was a trend over the grade levels on the print battery from no significance in Grade four to significance in Grade five and six.

Hypothesis 10

There is no significant difference in the correlation between reading comprehension scores and classification scores over the three grade levels.

The hypothesis was accepted.

The correlations between classification and reading comprehension scores did not change significantly over the grade levels.

On one subtest, concrete class inclusion there was a significant change between the correlations of Grade four and Grade five, and Grade six and Grade five. These results seemed to be quite different from those of other subtests, and may have been due to special effects of the subtest itself or of the Grade five group's performance on that subtest in comparison to their performance on other subtests.

It may be concluded that there are some differences between the correlations between reading comprehension scores and classification scores over the three grade levels, but these are not significant except in the concrete class inclusion subtest.

III. ANALYSIS OF THE CLASS INCLUSION SUBTEST

A special analysis of the class inclusion subtest was carried out because of the difference in results on this subtest compared to other subtests, especially by the Grade five and Grade six groups.

It was found that the Grade five group did poorer on the class inclusion subtest than on the other subtests relative to the other two groups. That this could be due to the relatively poorer abstracting ability of this group was postulated.

The Grade six group were found to be more competent at explaining class inclusion questions than the other two groups. It was postulated that this was due to their more mature level of operational thought as defined by Piaget (1964).

Specific types of class inclusion operations were compared and the effect of explanations on the score was examined.

IV. LIMITATIONS OF THE STUDY

1. Generalizations are applicable only to a population of

children in Grades four, five and six in an area similar to those in the one school in Edmonton which was used in this study.

2. Generalizations are applicable only to classificatory operations similar in nature to those used in the testing instruments used in this study.

V. IMPLICATIONS OF THE STUDY

1. The results of this study indicate that grade four, five and six children perform poorly on print classification tasks. It seems, therefore, that if it is possible, classification operations in a print mode (see Appendix E) need to be improved in these grades.

2. The tests used in this study could be used in diagnosing reasons for learning difficulties insofar as measuring a student's ability or inability to do thinking of a classificatory nature with concrete and/or print stimuli.

3. The results of this study indicate that teachers who make use of the concrete mode to assist students in understanding print concepts must be cognizant of the gap that exists between students' understanding of print and concrete tasks, and that a child's understanding of a concept in one mode may very likely not mean he will understand that same concept in the other mode. This means, for example, that in addition to teaching children a concept by employing objects that can be manipulated, the teacher must also teach the concept using print symbols. A specific example from mathematics is teach 2 X 4 using objects, and also teach using the print symbols, 2 X 4.

VI. SUGGESTIONS FOR FURTHER RESEARCH

1. A replication of this study with a sample chosen from a population with a different experiential background (e.g., rural) would reveal what effect experience has upon the scores.

2. There is a need to compare results when the manipulative materials used in the concrete test and the verbal materials used in the stories are the same.

3. There is a need to further revise the scoring method. One technique which might be tried would be to establish a scoring system that rewards varying degrees of correctness with a scale of scores. Another technique which might be tried would be to vary the weighting of scores in accordance with the speed with which a child answers the questions.

4. There is a need to revise the subtest items so that there would be an equal number of questions in each subtest, and examine the effect this has on the analyses.

5. There is a need to compare scores of children who are able to manipulate the objects with those scores of children for whom the objects are covered up. This may reveal the effect that counting the objects would have on the score.

6. There is a need to study the effect that training in classificatory operations would have upon the scores. Students could be trained to do concrete classification tasks, print classification tasks, or both, and their performance measured by means of a test-retest instrument.

Additional study that would be helpful would be to determine if training in one mode helps in only that mode or if there is transfer to the other mode not trained.

Another study could be to determine if there is a transfer from training in classification skills to general reading comprehension activities, to classificatory reading comprehension activities, or both.

7. There is a need to examine students' performance on these classificatory tasks using more modes: real objects, three-dimensional symbols of real objects, pictorial symbols of real objects, and word symbols of real objects.

Piaget has used real objects and pictures in classification tasks as if they are equally concrete. However, McRae discovered pictures could be as "abstract" as words in his study of inductive thinking.

8. There is a need to examine the effect of different learning styles as they relate to performance on classificatory tasks in different modes.

9. There is a need to examine the relation between speed of reading and quality of performance.

10. There is a need to further analyse the wording of the questions used on the classification tests. What effect does the wording of the questions have upon performance, for example, words such as more, some, all, and one of? What effect does the sequence of questions have upon the students' performance?

11. There is a need to develop questions which will measure those classificatory operations which were not measured in the tests used in this study.

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APPENDICES

APPENDIX A

TEN CHARACTERISTICS OF TRUE CLASSIFICATION WITH THOSE PRESENT AT THE CONCRETE STAGE ASTERISKED

*1. There must be no isolated elements left over after a group of elements has been classified.

*2. There must be no isolated classes. For every class A there must exist its complementary class A' (not A).

*3. The class A must include all those elements having the property a. (extension)

*4. The class A must include only those elements having the property a.

*5. All classes of the same rank must be disjoint.

*6. A complementary class A' has its own characteristics which are not possessed by its complement A.

*7. Any class A is included in every higher ranking class which contains all its elements plus other elements.

8. There is an effort toward extensional simplicity in which the inclusions are reduced to the minimum compatible with the intensional properties.

9. Intensional simplicity, or use of similar criteria which distinguish classes of the same rank, becomes a goal.

10. One finds symmetrical subdivision. If a class B_1 is subdivided into A_1 and A_1' and the same criterion is applicable to B_2, then B_2 must likewise be subdivided into A_2 and A_2'.

Blackford (1970, pp. 14,15)

APPENDIX B

MATERIALS FOR PRINT BATTERY

MATERIALS FOR CONCRETE BATTERY

MATERIALS FOR PRINT BATTERY

Story 1

The Ducks Arrive in Spring

Every spring the prairies become a fly-way for the birds on their way north for the summer.

The first birds to arrive are ducks, and the first ducks are the pintail. There will be ice on the ponds and lakes and some snow still on the fields when the pintail fly in in April. But these ducks can live off the land. They eat the seeds they find in the yellow stubble of the wheat fields until the ice melts. The pintail come in flocks of hundreds, long black lines of ducks against the blue prairie sky. They circle, then drop into the snowy fields.

The next ducks to arrive are the pond-feeders. They need weedy pools that are not very deep. These are the mallard, teal and shoveller. They swim on the surface of shallow ponds and bob their heads under the water to feed. These ducks must wait for the ice to melt on the shallow pools and ponds. As soon as the ice is melted, the pintail will leave the fields and swim about on the pools with the mallard and teal. They are pond-feeders.

The last ducks to arrive are the diving ducks. These are canvas backs, red-head, and golden eyes. Diving ducks must wait for the ice to go out on the lakes and rivers. They dive into deep water to get their food.

Story 2

A Story of Long Ago

Many thousands of years ago, there lived a people in India who built beautiful cities. Their streets were straight, like ours, and the streets met at corners like ours. But these people made a long curve at the corner of their streets and built a house there. So this house on the corner belonged to both streets. It looked up one street and it looked down the other. It belonged to both streets.

People came from far away to live on the streets of this beautiful city. Some families came down the river on rafts from their villages in the mountains. Some families travelled on foot for many days through the forests. Every family who came on foot carried some small treasure to remind them of their old homes.

In the strange, new city families from the same village liked to live near one another, to be near their friends. So it happened that everyone along one street came from the same village. They had travelled together for many days through the forest. And everyone along the other street had come together down the river on rafts from their village in the mountains.

The forest people set out their treasures in front of their houses. These were treasures they had carried with them from their old homes. Every treasure was painted a bright yellow color to show how happy the family was to reach the great city. There was an old church bell in front of one house. It was painted bright yellow. An old axe was in front of another house. It was bright yellow, too. In front of another house there was a tall post carved with the strange signs the people used for letters in those days. It was yellow, too. Every house had its bright yellow treasure set out in front for all to see.

In front of every house on the other street was the family's old waterlogged raft. They had come down the river on that raft and they treasured it. They wanted everyone to see it, just as it was. All along this street was a row of river rafts.

There was only one house that had no treasure set out in front for all to see. That was the house at the corner which belonged to both streets. It looked up the street with all the yellow treasures and down the street with all the rafts. What could this family put out for everyone to see? They wanted to show that they belonged to both streets, because they lived where the two streets met. No one could think how this could be done. No one could think what to put out in front of the house at the corner where the two streets met.

READABILITY OF THE STORIES

The readability of the stories was estimated by Rawson using the Dale-Chall Readability Formula. The results are presented in Table 18 below. The calculations in each case are based on a complete story text.

TABLE 18

READABILITY SCORES FOR THE PRINT TEST MATERIALS[*]

Story	Average Sentence Length	Dale Score	Readability Grade Score
Ducks	12	5	5.02
City	12	1	4.39

[*] Rawson, 1969, p. 92.

MATERIALS FOR CONCRETE BATTERY

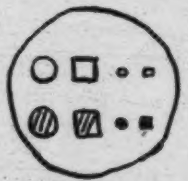
Materials for Questions 1 - 8:

14 square cardboard display supports, black, side 12"
10 round counters, red, diameter 2"
3 round counters, white, diameter 2"
3 square counters, red, side 2"
3 square counters, white, side 2"

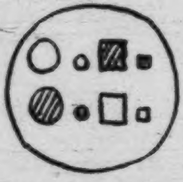
Materials for Questions 9 - 11:

1 yellow rod, length 12", width 1/2"

Pattern I



Pattern II

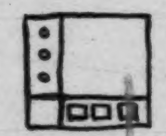


Materials for Questions 12 - 13:

2 white rods, length 12", width 1/2"
5 round counters, red, diameter 1 1/4"
4 round counters, white, diameter 1 1/4"
4 square counters, red, side 1 1/4"
3 square counters, white, side 1 1/4"

Materials for Questions 14 - 15:

Pattern III



2 round counters, white, diameter 2"
2 square counters, white, side 2"
1 square counter, black, side 2"
1 round counter, red, diameter 1 1/4"
3 round counters, white, diameter 1 1/4"
1 square counter, red, side 1 1/4"
1 square counter, black, side 1 1/4"
3 square counters, white, side 1 1/4"

APPENDIX C

SYMBOLIC REPRESENTATION OF THE TEST ITEMS FOR THE PRINT AND CONCRETE BATTERIES

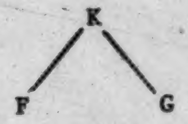
LOGICAL SYMBOLS USED IN THIS STUDY

Symbol	Meaning
∧	signifies a particular class
A, B, C, D, etc.	signifies a class
a, b, c, d, etc.	signifies a property of a member of a class
θ, ∅, ψ	signifies a proposition
:	read "such that"
∾	read "not"
∃	read "some"
>	read "more"
&	read "and"
ε	read "member of a class"
⊃	read "implies: if . . . than"
⊂	read "is contained in"
≡	read "is equivalent to"
( )	used as in mathematics
=, -, +, X	read as in mathematics

SYMBOLIC REPRESENTATION OF LOGICAL OPERATIONS MEASURED IN THIS STUDY

Operation	Symbolic Representation and Meaning
1. abstraction	$(\hat{X}): f_{(x)}$ x is a member of the class $\hat{X}$ if it has the property f
2. predicate	$\phi x, \ldots, \phi \hat{X}$ This (these) x is (are) in the class $\hat{X}$.
3. quantification	
(i) complete class exclusion	$(x): (x \epsilon A) \supset \overline{(x \epsilon B)}$ For every x, x is a member of A and not a member of B.
(ii) partial class inclusion	
(a) type '1'	$(x): (x \epsilon A) \; \& \; (\exists x \epsilon B)$ For every x, all x are members of A and some x are members of B.
(b) type '2'	$(x): (x \epsilon A) \; \& \; (\exists x \epsilon B) \equiv B < A$ For every x, x is a member of A, and some x are members of B, if and only if B is contained in A.
(iii) joint class inclusion	$(\exists x): (x \epsilon A) \; \& \; (x \epsilon B)$ There are some x such that x is a member of A and x is a member of B.
(iv) partial class exclusion	$(\exists x): (x \epsilon A) \; \& \; \overline{(x \epsilon B)}$ There are some x such that x is a member of A and x is not a member of B.

(v) complete class inclusion	
(a) type '1'	$A \subseteq B$ Every A is a B and every B is an A.
(b) type '2'	$B \subset C$ B is contained in A.
4. addition	$\hat{K} = A \& B$ To obtain class $\hat{K}$ add B's members to A's.
5. multiplication	$\hat{K} = A \times B$ The class $\hat{K}$ is made up of the intersection of A and B.
6. complement	$\hat{B} = \hat{A} + (\widehat{-A})$ The class $\hat{B}$ is made up of members of A and not A.
7. empty class	$\otimes$ No members have the properties of the class.
8. hierarchical class structure and relations	$\hat{K} = \hat{F} + \hat{G}$ $\hat{K} - \hat{F} = \hat{G}$ $\hat{K} - \hat{G} = \hat{F}$ The class $\hat{K}$ is made up of the classes $\hat{F}$ and $\hat{G}$ such that a relation of this type exists:



9. matrix class structure and relations

	F	F
A	AF	AG
A'	A'F	A'G

The classes A and A' combine with the classes F and G to form intersecting classes.

MEANING OF SPECIAL SYMBOLS USED IN THIS STUDY

Property Symbols	Meaning	Class Symbols	Meaning
obs	object-ness	$\widehat{Obs}$	objects
c	circle-ness	$\hat{C}$	circles
s	square-ness	$\hat{S}$	squares
w	white-ness	$\hat{W}$	whites
r	red-ness	$\hat{R}$	reds
l	large-ness	$\hat{L}$	large things
sm	small-ness	$\widehat{Sm}$	small things
d	duck-ness	$\hat{D}$	ducks
b	bird-ness	$\hat{B}$	birds
pi	pintail-ness	$\widehat{Pi}$	pintails
pf	pondfeeder-ness	$\widehat{Pf}$	pond-feeders
di	diver-ness	$\widehat{Di}$	divers
lk	lake duck-ness	$\widehat{Lk}$	lake ducks
po	pond duck-ness	$\widehat{Po}$	pond ducks
e	early duck-ness	$\hat{E}$	early ducks
lt	late duck-ness	$\widehat{Lt}$	late ducks
bo	bobbing duck-ness	$\widehat{Bo}$	bobbing ducks
y	yellow-ness	$\hat{Y}$	yellows
wd	wooden-ness	$\widehat{Wd}$	wooden things
t	treasure-ness	$\hat{T}$	treasures
rt	raft-ness	$\widehat{Rt}$	rafts

Other symbols used are:

H - hierarchical class structure
CI - class inclusion
Pr - predicate
M - multiplicative

SYMBOLIC REPRESENTATION OF TEST ITEMS USED IN THIS STUDY

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
	CONCRETE BATTERY	
H B	$\widehat{Obs} = \hat{C} + \hat{S}$ $\widehat{Obs} - \hat{C} = \hat{S}$ $\widehat{Obs} - \hat{S} = \hat{C}$ or $\widehat{Obs} = \hat{R} + \hat{W}$ $\widehat{Obs} - \hat{R} = \hat{W}$ $\widehat{Obs} - \hat{W} = \hat{R}$	- hierarchical class structure and relations - abstraction
H C	$\hat{C} = r_{\hat{C}} + w_{\hat{C}}$ $\hat{S} = r_{\hat{S}} + w_{\hat{S}}$ $\hat{R} = c_{\hat{R}} + s_{\hat{R}}$ $\hat{W} = c_{\hat{W}} + s_{\hat{W}}$	- addition - abstraction
CI I	$(x):(x \in \hat{R})$ & $(\exists x \in \hat{C}) \equiv \hat{C} \subset \hat{R}$ Given any objects x such that every x is a member of reds and some x are members of circles, is equivalent to saying the class circles is contained in the class reds.	- partial class inclusion '2'
CI II	$(x): (x \in \hat{S})$ & $(\exists x \in \hat{R}) \equiv \hat{R} \subset \hat{S}$ Given any objects x such that every x is a member of squares and some x are members of reds, is equivalent to saying the class reds is contained in the class squares.	- partial class inclusion '2'

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
CI III	$\hat{W}\subseteq\hat{S}$ The class *whites* is contained in and equal to the class *squares*.	- complete class inclusion '1'
CI IV	$(x): (x\in\hat{R})\ \&\ (\exists x\in\hat{C}) \equiv C\subset R$ Given any objects *x* such that every *x* is a member of *reds* and some *x* are members of *circles* is equivalent to saying the class *circles* is contained in the class *reds*.	- partial class inclusion '2'
CI V	$(x): (x\in\hat{S})\ \&\ (\exists x\in\hat{R}) \equiv \hat{R}\subset\hat{S}$ Given any objects *x* such that every *x* is a member of *squares* and some *x* are members of *reds* is equivalent to saying the class *reds* is contained in the class *squares*.	- partial class inclusion '2'
CI VI	$(x): (x\in\hat{R})\ \&\ (\exists x\in\hat{C}) \equiv \hat{C}\subset\hat{R}$ Given any objects *x* such that every *x* is a member of *reds* and some *x* are members of *circles*, is equivalent to saying the class *circles* is contained in the class *reds*.	- partial class inclusion '2'
CI VII	$\hat{W}\subseteq\hat{S}$ The class *whites* is contained in and equal to the class *squares*.	- complete class inclusion '1'
CI VIII	$\hat{C}\subseteq\hat{R}$ The class *circles* is contained in and equal to the class *reds*.	- complete class inclusion '1'

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
Pr IX	$\phi r, \ldots, \phi\hat{R}$ The things that are red are reds. $\beta w, \ldots, \beta\hat{W}$ The things that are white are whites.	- predication
Pr X	$\psi l, \ldots, \psi\hat{L}$ The things that are large are large things. $\gamma s, \ldots, \gamma\hat{S}$ The things that are small are small things.	- predication
Pr XI	$\theta c, \ldots, \theta C$ The things that are round are circles. $\lambda s, \ldots, \lambda\hat{S}$ The things that are square are squares.	- predication
M XII	$\begin{array}{c\|c} c^{\wedge}_{R} & s^{\wedge}_{R} \\ \hline c^{\wedge}_{W} & s^{\wedge}_{W} \end{array}$	- matrix class structure and relations - abstraction
M XIII	$(c \& s) \times (r \& w) =$ $(c \times r) \& (c \times w) \&$ $(s \times r) \& (s \times w) =$ $c^{\wedge}_{R}$ or $r^{\wedge}_{C}$ & $c^{\wedge}_{W}$ or $w^{\wedge}_{C}$ & $s^{\wedge}_{R}$ or $r^{\wedge}_{S}$ & $s^{\wedge}_{W}$ or $w^{\wedge}_{S}$	- multiplication - abstraction

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
M XIV and M XV	$(\hat{C}\ \&\ \hat{S})\ X\ (\hat{L}\ \&\ \hat{Sm}) =$ $(\hat{C}\ X\ \hat{L})\ \&\ (\hat{C}\ X\ \hat{Sm})^{*}\ \&$ $(\hat{S}\ X\ \hat{L})^{*}\ \&\ (\hat{S}\ X\ \hat{Sm}) =$ $c_{\hat{L}}$ or $1_{\hat{C}}$ & $c_{\hat{Sm}}$ or $sm_{\hat{C}}$ & $s_{\hat{L}}$ or $1_{\hat{S}}$ & $s_{\hat{Sm}}$ or $sm_{\hat{S}}$ *These were given in the question.	- multiplication - abstraction

PRINT BATTERY

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
CI 1	$\hat{D}\subset\hat{B}$ The class ducks is contained in the class birds.	- complete class inclusion '2'
CI 2	$\hat{Pf}\subset\hat{D}$ The class pondfeeders is contained in the class ducks.	- complete class inclusion '2'
CI 3	$(x):(x\epsilon\hat{D})\ \&\ (\exists x\ \epsilon\ \hat{Di})\equiv\hat{Di}\subset\hat{D}$ Given any thing x such that every x is a member of ducks, and some x are members of divers, is equivalent to saying the class divers is contained in the class ducks.	- partial class inclusion '2'
CI 4	$(x):\ (x\epsilon\hat{B})\ \&\ (\exists x\epsilon\hat{D})\equiv\hat{D}\subset\hat{B}$ Given any thing x such that every x is a member of birds, and some x are members of ducks, is equivalent to saying the class ducks is contained in the class birds.	- partial class inclusion '2'

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
CI 5	$\hat{Pi} \subset \hat{D}$ The class pintails is contained in the class ducks.	- complete class inclusion '2'
CI 6	$(x):(x \epsilon \hat{D})$ & $(\exists x \epsilon \hat{Pi}) \equiv \hat{Pi} \subset \hat{D}$ Given any thing x such that every x is a member of ducks, and some x are members of pintails, is equivalent to saying the class pintails is contained in the class ducks.	- partial class inclusion '2'
CI 7	$\hat{D} \subset \hat{B}$ The class ducks is contained in the class birds.	- complete class inclusion '2'
CI 8	$(x):(x \epsilon \hat{B})$ & $(\exists x \epsilon \hat{D}) \equiv \hat{D} \subset \hat{B}$ Given any thing x such that x is a member of birds, and some x are members of ducks, is equivalent to saying the class ducks is contained in the class birds.	- partial class inclusion '2'
Pr 9	$\phi e, \ldots, \phi \hat{E}$ The ducks that arrive early are early ducks. $\beta lt, \ldots, \beta \widehat{Lt}$ The ducks that arrive late are late ducks	- predication

<table>
<tr><th>Subtest and Test Item</th><th>Symbolic Representation</th><th>Classification Operation Measured</th></tr>
<tr><td>Pr 10</td><td>$\Psi lk, \ldots, \Psi\hat{Lk}$
The ducks that live on the lakes are lake ducks.
$\gamma po, \ldots, \gamma\hat{Po}$
The ducks that live on ponds are pond ducks.</td><td>- predication</td></tr>
<tr><td>Pr 11</td><td>$\theta di, \ldots, \theta\hat{Di}$
The ducks that dive are divers.
$\lambda bo, \ldots, \lambda\hat{Bo}$
The ducks that bob are bobbers.</td><td>- predication</td></tr>
<tr><td>M 12</td><td>$\begin{array}{c|c} po_{\hat{Bo}} & \otimes \\ \hline \otimes & lk_{\hat{Di}} \end{array}$</td><td>- matrix class structure and relations
- empty class
- abstraction</td></tr>
<tr><td>M 13</td><td>$(\hat{Bo} \ \& \ \hat{Di}) \ X \ (\hat{Po} \ \& \ \hat{Lk}) \rightarrow$
$(\hat{Bo} \ X \ \hat{Po}) \ \& \ (\hat{Bo} \ X \ \hat{Lk}) \ \&$
$(\hat{Di} \ X \ \hat{Po}) \ \& \ (\hat{Di} \ X \ \hat{Lk}) =$
$po_{\hat{Bo}}$ or $bo_{\hat{Po}}$ & $\otimes$ &
$\otimes$ & $di_{\hat{Lk}}$ or $lk_{\hat{Di}}$</td><td>- multiplication
- abstraction</td></tr>
</table>

Subtest and Test Item	Symbolic Representation	Classification Operation Measured
M 14 and M 15	$(\hat{Y} \,\&\, \widehat{Wd})\ X\ (\hat{T} \,\&\, \widehat{Rt}) =$ $(\hat{Y}\ X\ \hat{T})^* \,\&\, (\hat{Y}\ X\ \widehat{Rt}) \,\&$ $(\widehat{Wd}\ X\ \hat{T}) \,\&\, (\widehat{Wd}\ X\ \widehat{Rt})^* =$ $y_{\hat{T}}$ or $t_{\hat{Y}}$ & $y_{\widehat{Rt}}$ or $rt_{\hat{Y}}$ & $wd_{\hat{T}}$ or $t_{\widehat{Wd}}$ & $wd_{\widehat{Rt}}$ or $rt_{\widehat{Wd}}$	- multiplication - abstraction

*were given in question

APPENDIX D

PRINT CLASSIFICATION TEST BATTERY

CONCRETE CLASSIFICATION TEST BATTERY

PRINT TEST OF CLASSIFICATION

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	Students read the story The Ducks Arrive in Spring silently. He may look back in the story for the preliminary questions if desired.		
	Preliminary Questions		
	a. This is a story about the birds that come to the lakes and ponds of the prairie in the spring. What kind of birds come back first in the spring?	ducks	-
	b. What kind of ducks arrive first?	pintail	-
	c. What is the weather like when the pintail arrive?	cold	-
	d. How do the pintail get their food when they arrive?	off the fields	-
	e. Why do they feed off the wheat fields?	ice on ponds	-
	f. Where do they feed when the ice melts?	on ponds	-
	g. Which ducks come next after the pintail?	mallard, teal, and shoveller	-
	h. Where do the mallard, teal, and shoveller get their food?	ponds	-
	i. How do they get their food?	bob	-
	j. What kind of ducks arrive after the mallard, teal, and shoveller?	canvas-back, red-head, golden-eye	-

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	k. Where do the canvas-back, red-head, and golden-eye get their food?	lakes, rivers	-
	l. How do they get their food?	dive	-
	m. Why do they come last?	lakes melt later than ponds	-
	The story is covered.		
	Test Questions		
Class Inclusion Relations	1. In this story are there more ducks or more birds on the prairie in the summer?	birds	1
	1a. How did you know that?	must be aware that ducks are part of the family of birds	1
	2. In this story, are all pond feeders ducks?	yes	1
	2a. Why do you say that?	must be aware that all the pond feeders in the story are part of the family of ducks	1
	3. In this story, are all ducks divers?	no	1
	3a. How do you know that?	must be aware that in the duck family only some are divers and some are not	1
	4. In this story, are some birds ducks?	yes	1

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	4a. Why do you say that?	must be aware that in the bird family some are ducks and the rest are other birds	1
	5. In this story, are all pintails ducks?	yes	1
	5a. Why?	must be aware that the pintails belong to the duck family	1
	6. In this story, are there more ducks or more pintail on the prairie in the summer?	ducks	1
	6a. How did you know that?	must be aware that pintail are only some of the ducks and there are other ducks in the duck family	1
	7. In this story, are all ducks birds?	yes	1
	7a. Why do you say that?	must be aware that ducks are part of the bird family	1
	8. If all the birds left the prairie and flew into the far north, would there be some ducks on the prairie?	no	1
	8a. Why is that?	must be aware that ducks are part of the bird family	1

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
Predicates	Test Questions		
	9. What are two different kinds of ducks that come to the prairie? Put the ducks you read about into two different kinds or lots. You can do this without using their names. Describe them. What would be two kinds of ducks that come to the prairie in the spring?	time of arrival: early and late OR favorite habitat: pond and lake OR feeding method: divers and bobbers	1
	10. Tell me another way to describe the kinds of ducks that come back in the spring? Put the ducks into two different kinds or lots in another way and describe them.	one of the above choices but not the same one	1
	11. There is still another way to describe the kinds of ducks that come back in the spring. Put the ducks into two lots in another way and describe them.	one of the above choices but not the same as is 9 or 10	1
Multiplicative Classes	Test Questions		
	12. Imagine that you are driving along the highway and you see shallow ponds along the road and you see a lake not far away. What kinds of ducks will live in this neighborhood?	both pond feeders and diving ducks (no names)	1

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	13. Explain why each type of duck will live in the neighborhood.	must be aware that pond feeders will be on the ponds and diving ducks will be on the lakes	1
	Student reads A City of Long Ago silently. He may look back in the story for the preliminary questions if desired.		
	Preliminary Questions		
	a. This is a story about a city that was built by people in India a long time ago. It was a beautiful new city and many people came to live there. How did the people travel who came down the river?	raft	-
	b. What is a raft?	description of a raft	-
	c. Where did these people put the rafts?	in front of their house	-
	d. Why did they do that?	proud of it	-
	e. How did the people travel who came through the forest?	foot	-
	f. What did they carry with them?	treasures	-
	g. What color did they paint their treasures?	yellow	-
	h. Why did they paint them yellow?	happy to reach the city	-

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	i. Where did they put them?	in front of their house	-
	The story is covered.		
	Test Questions		
	14. So we have two streets: the street with the rafts, and the street with the yellow treasures. These two streets meet at the corner.		
	Gesture a right angle on the table.		
	You remember the family that live at the corner where the two streets meet. What is the right thing for them to set out in front of their house? They want to show that they belong to both streets: the street with the rafts and the street with the yellow treasures.		
	Gesturing the right angle again.		
	What one thing should they put out?	yellow raft OR wooden treasure	1

Subtest	Method of Presentation and Questions	Criteria of Correctness	Score
	14a. How does it belong to this street? Gesture in one direction. How does it belong to this street? Gesture in the other direction at right angles to first.	must choose something that has at least one quality that is like each street	1
	15. Is there another one thing that this family could put out to show that they belong to both the street with the rafts and the street with the yellow treasures?	one of the above choices but not the same one	1
	15a. How does it belong to both streets? Gesturing in one direction and then in the other.	same as for 14a	1

CONCRETE TEST OF CLASSIFICATION

Method of Presentation and Questions	Criteria of Correctness	Score
A collection of objects is dumped on one board.		
Hierarchical Class Structure Preliminary Questions		
A. What objects are in this collection?	objects identified	-
The collection is covered.		
B. I am going to ask you to put these objects into two lots. Everything in one lot is to belong together and everything in the other lot is to belong together.	squares and circles	1
	OR	
	reds and whites	
Two boards are placed below the board with the collection of objects.		
What will you put here?	as above	-
Pointing to one of the boards.		
What will you put here?	as above	-
Pointing to the other board.		
The collection is uncovered and the student is asked to put the objects into two lots.		
What objects are in this lot? What objects are in this lot?	as above	-
The two lots are covered, and the student asked again what is in the lots.		

Method of Presentation and Questions	Criteria of Correctness	Score
C. I am going to ask you to make four lots from these two lots of objects, two from this lot, and two from this lot. Everything in each lot must belong together.		
Four boards are placed below the two lots.		
What will you put in this lot? Pointing to one board.	one of: red circles, white circles, red squares, or white squares	
What will you put in this lot? Pointing to a second board.	as above, but different	
And this lot? Pointing to a third board.	as above, but different	
And this one? Pointing to the fourth board.	as above, but different	1

The two lots are uncovered and the student is asked to put the objects into four lots.

Class Inclusion Relations Test Questions

The examiner states that the white rounds are to be removed. They are placed at ~~the~~ upper right. The four lots are covered.

The student is asked to name the four lots and reminded that the white rounds have been removed from the other lots.

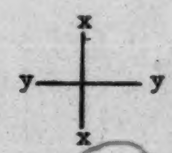
	Method of Presentation and Questions	Criteria of Correctness	Score
I.	In these lots are there more red ones or more round ones?	red	1
Ia.	Why?	must compare the quantity of lots which are red with the quantity which are red and round	1
II.	In these lots are all the square ones red?	no	1
IIa.	Why?	must be aware of two colors of square ones	1
III.	In these lots are all the white ones square?	yes	1
IIIa.	Why. How did you know?	must be aware that there were two white sets and the rounds were removed leaving only the squares	1
IV.	In these lots are some of the red ones round?	yes	1
IVa.	How did you know?	must be aware that there are two kinds of red ones and some are round; or, that of two lots of red ones, one lot is round	1
V.	In these lots if I am going to give you a square one, will it have to be red?	no	1
Va.	Why?	must be aware that there are two colors of square ones	1

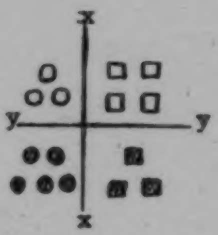
Method of Presentation and Questions	Criteria of Correctness	Score
VI. In these lots, if I am going to give you a red one, will it have to be round?	no	1
VIa. Why is that?	must be aware that there are two different shapes of red ones	1
VII. In these lots if I am going to give you a white one, will it have to be square?	yes	1
VIIa. Why is that?	must be aware that there were two white sets and the rounds were removed leaving only squares	1
VIII. In these lots if I am going to give you a round one, will it have to be red?	yes	1
VIIIa. Why?	must be aware that there were two colors of rounds and that the whites were removed leaving only reds	1
The boards and objects are removed.		
Predicates Test Questions		
Pattern I is presented.		
Ask: What is the design here?	objects identified	-
IX. This is a design a boy/girl made. He/she has put together what belongs together to make a pattern.		

Method of Presentation and Questions	Criteria of Correctness	Score
A rod is handed to the student.		
Take this rod and put it on the design to show how he/she has put together what belongs together.		
What pattern does the rod help you see?	size or color	1
How do these belong together? Pointing to one section.	large and small or red and white	-
How do these belong together? Pointing to the other section.	as above	-
X. Is there another way to lay the rod to show a pattern?	size or color but not the same as in IX	1
How do these belong together? Pointing to one section.	as above	-
How do these belong together? Pointing to the other section.	as above	-
Pattern I is removed.		
Pattern II is presented.		
Ask: What is the design here?	objects identified	-
XI. This is another design that a boy/girl made. He/She has put together what belongs together to make a pattern.		

Method of Presentation and Questions	Criteria of Correctness	Score
A rod is handed to the student.		
Take this rod and put it on the design to show how he/she has put together what belongs together.		
What pattern does the rod help you see?	shape	1
How do these belong together?		
Pointing to one section.	round or square	-
How do these belong together?		
Pointing to the other section.	one of the above but a different choice	-
Pattern II is removed.		

Multiplicative Classes
Test Questions

Method of Presentation and Questions	Criteria of Correctness	Score
A collection of objects is dumped on a board.		
Ask: What objects are in this collection?	objects identified	-
The collection is covered.		
Two rods are laid on a board as shown. The rods shall be labelled x - x and y - y.		
Ask: How many sections are there?	4	-
When I pick up this rod, how many sections are there?	2	-
Rod x - x is lifted and replaced.		
When I pick up this rod, how many sections are there?	2	-

Method of Presentation and Questions	Criteria of Correctness	Score
Rod y - y is lifted and replaced.		
And how many sections are there?	4	-
Put these counters into these four sections.		
Pointing to the covered collection and then to each of the four sections.		
Everything in each section must belong together. Put them so that if I pick up this rod . . .		
Rod x - x is lifted and replaced.		
the objects are in a good order; and if I pick up this rod . . .		
Rod y - y is lifted and replaced.		
they are in a good order.		
What will you put in this section?		
Pointing to one section.		
And these sections?		
Pointing to each of the other sections.		1
The collection is uncovered and the student asked to put the counters into the sections.		
XIII. Are they in good order when I pick up this rod?	color or shape	1
Rod x - x is lifted and replaced immediately.		
Are they in good order when I pick up this rod?	color or shape but different than above	
Rod y - y is lifted and replaced immediately.		

Method of Presentation and Questions	Criteria of Correctness	Score
Why is that?	as above	-
NOTE: Two attempts to correct the order are permitted if the student recognizes that the classes are diagonally positioned.		
The materials are removed.		
Pattern III is presented.		
Ask: What is the design here?		
XIV. This is a pattern a boy/girl made. He/She didn't finish it. He/She didn't put anything here.		
Pointing to the empty space at the point of intersection.		
We want to put something there; one thing. It must belong to this row . . .		
Gesturing along the row of large squares.		
and it must belong to this row.		
Gesturing along the row of small circles.		
What will you put there?		
Pointing to the empty space.	white object or small square or large circle	1
XIVa. Why? How does it belong to this row? And to this row?		
Pointing to each row.	must choose something that has at least one quality that is like each row	1

Method of Presentation and Questions	Criteria of Correctness	Score
XV. What else could we put in this space that would belong to this row and belong to this row?	as for XIV, but a different one	1
Pointing to the empty space at the point of intersection, and then to each row of objects.		
XVa. How does it belong to this row? And to this row?	as for XVa.	1
The collection is uncovered. The student is asked to select any counter or counters that could fit into the space of intersection and explain how those selected belong to each row.		
The materials are removed.		

APPENDIX E

SUMMARY OF THE TWO TEST BATTERIES SHOWING THE PARALLEL CONSTRUCTION

Operations Items Measure	Concrete Items	Print Items
1. abstraction	B, C, XII, XIII	12, 13
2. predicates	IX, X, XI	9, 10, 11
3. quantification		
i. complete class exclusion	-	-
ii. partial class inclusion		
a. type '1'	-	-
b. type '2'	I, II, IV, V, VI	3, 4, 6, 8
iii. joint class inclusion	-	-
iv. partial class inclusion	-	-
v. complete class inclusion		
a. type '1'	III, VII, VIII	-
b. type '2'	-	1, 2, 5, 7
4. addition	B, C	-
5. multiplication	XIV, XV	14, 15
6. complement	-	1, 2, 5, 7
7. empty class	III, VII, VIII	12, 13
8. hierarchical class structure and relations	B, C, I - VIII	1 - 8
9. matrix class structure and relations	XII, XIII	12, 13